GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Date: 6/30/71

Project Title: A Study to Analyze the Alumina from Kaolin Potentials

Project No.: A-1343

Project Director: W. C. Ward, Jr.

Sponsor: Georgia Department of Industry and Trade

Effective . . . June 28, 1971 . . . . Estimated to run until: . . . . April 30, 1972 . . . . . .

Type Agreement: Industrial Development Agreement . . . . Amount: $ 35,000* . . . .

*Plus Georgia Tech Contribution of $3,000.

Reports: Monthly Letter Reports
Final Report (Camera ready copy required)

Contact Person: Georgia Department of Industry and Trade
Trinity Washington Building
Atlanta, Georgia 30334

Attn: Mr. Richard Millsups (for fiscal matters)
Attn: Mr. James Bohanan (for technical matters)

Assigned to . . . . Industrial Development . . . . Division

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GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT TERMINATION

Date May 16, 1972

PROJECT TITLE: A Study to Analyze the Alumina from Kaolin Potentials

PROJECT NO: A-1343

PROJECT DIRECTOR: William C. Ward, Jr.

SPONSOR: Georgia Department of Industry and Trade

TERMINATION EFFECTIVE: April 30, 1972

CHARGES SHOULD CLEAR ACCOUNTING BY: All acceptable charges have cleared.

INDUSTRIAL DEVELOPMENT DIVISION

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ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

28 July 1971

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During July most of the project time was used for preliminary preparations which are essential to get a study off to a successful start, such as:

1. Preparation of a project plan of action

2. List of information required

3. Preparation of questions to be asked during interviews

4. List of contacts to be made

5. Accumulation of data

A meeting was held at the Georgia Department of Industry and Trade with General Truman, Harold A. Dye, and James O. Bohanan to discuss the project and coordinate with the sponsor. The project plan was discussed and many helpful suggestions were received.

Phases I and II have been initiated with preliminary data searches and interviews. The project team has obtained secondary source information pertaining to aluminum production in the U. S., U. S. imports of bauxite, forecasted demand for aluminum to the year 2000, world production of bauxite, and estimates of world kaolin and bauxite reserves. Also preliminary raw material and energy data is being collected to establish cost requirements for an economic comparison of bauxite and kaolin.

Data relative to taxes, duties, tariffs and royalties is projected as a problem area at this point. However, interviews with leading aluminum companies should mitigate these problems.

Information has been received that there was a high-level meeting on July 1, 1971 of Department of the Interior officials and executives of the U. S. aluminum industry to discuss a recommendation from the National Materials Advisory Board that pilot plants for producing alumina from domestic raw materials be built and operated by the Interior Department's Bureau of Mines, with industry cooperation. Contact with the U. S. Bureau of Mines revealed that no decision was reached at this meeting, but the U. S. Bureau of Mines is submitting a proposal to the Aluminum Association in New York, N. Y. for consideration.

Dr. John E. Husted, Head, Mineral Engineering Branch, Engineering Experiment Station, has planned a series of meetings in Washington, D. C. and New York, N. Y., the week of 9 August 1971 to collect information from government and industry officials. He will determine the status of the proposed pilot plant project at that time. It would be advantageous to the State of Georgia to influence the location of such a pilot plant in the kaolin belt of Georgia. Two of the three favorable areas outlined in the report of the National Materials Advisory Board are located in Georgia. The report stated: "The most likely areas where clay containing approximately 35 percent alumina and in deposits of 50 million tons or more can be considered available for aluminum are: (1) the Georgia-South Carolina kaolin belt in which deposits are of Cretaceous Age; (2) a belt of Eocene Age deposits which includes the Andersonville district, Georgia, and extends northeast and southwest of this area; and (3) the Arkansas bauxite region. The total kaolin resources in Georgia which include the first two areas has been estimated mainly on geologic inferences to be as much as 3 billion tons."

The Kaolin Research being conducted by the Georgia Department of Mines, Mining and Geology, should provide the necessary refinements needed as to location, quantity and quality of kaolin in Georgia.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:erl

cc: Mr. Ross Hammond
Mr. John E. Husted
ORA (2)
Mr. Gerald Pitalo
File A-1343

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

27 August 1971

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During August the project team concentrated on gathering data and verifying information received. Major efforts were expended in the following areas:

1. Defining the future demand for aluminum.

   Using data published by the U. S. Bureau of Mines the demand for aluminum to the year 2000 has been identified. The technological forecast indicates a demand of 9 to 12.7 million tons of domestic production for 1985. This is an increase of 2 to 3 times the 1970 level. This forecast is relevant to this study for two reasons.

   a) It is the base for the estimate of the outflow of dollars paid for raw materials imported to meet the demand, and

   b) in relation to the world demand, which is growing rapidly, the ability of the U. S. to compete for foreign sources will require additional investments overseas to assure supplies, which will add to the outflow of dollars.

   The estimates of world demand for aluminum for 1985 range from 22 to 35 million tons. Domestic resources which could be utilized would only provide 6 to 8% of the required production. The remaining production would require overseas supplies which are sensitive to competition and the political climates of the underdeveloped countries in which they are found.

   The relationships and dollar outflow figures need further refinement. An investigation of these will be made this next month.

2. Federal subsidization of a pilot plant to produce alumina from kaolin.

Interviews with government officials and aluminum industry representatives have revealed the following:

a) the aluminum industry wants a highly visible federal effort to check out certain process economies. They are willing to lend their experience and research data if the federal government would commit substantial funding to such a program.

b) the federal agencies which would be involved in this effort have only limited funds at this time. However, there is interest in the project at the highest level.

Contacts as of this date have been with the following agencies and companies:

U. S. Bureau of Mines
Office of Minerals and Solid Fuels
Assistant Secretary of the Interior, Mineral Resources
Defense Supply Agency
Department of Defense
Office of Emergency Preparedness
The Anaconda Company
The Aluminum Association
Kaiser Aluminum Company
Pechinet
Amax Aluminum Company
Thiele Kaolin Company
Sandersville Railroad Company

Next month interviews are planned with:

Alcoa, Reynolds, Huber Kaolin, Georgia Kaolin

3. Factors crucial to the location of an alumina facility.

From our discussions with knowledgeable people in both the kaolin industry and the aluminum industry indications are that depletion allowances, investment tax credits, financial aid, tax structures, power costs, and transportation costs are areas which will affect the decision of a company wanting to develop a domestic source of alumina. The risk attendant to investing in an economically unproven process is so great that assistance in the form of low cost funds would be required. Because of this risk factor the availability of financial aid would have the greatest affect in locating an alumina facility.

The various areas will be explored more fully in the ensuing months. However, preliminary indications are that financial aid, investment tax credits, and depletion allowances will be the factors which will have the highest priorities in this project.

It was stated in our 28 July 1971 report that Dr. John E. Husted would determine the status of the proposed pilot plant project during a visit to Washington, D. C. and New York, N. Y. this month. As a result of information obtained, it has been determined that the National Materials Advisory Board recommendations are currently under active review by the Department of the Interior with a decision expected to be made by the middle of October. Diverse points being considered are:

Unfavorable

(1) There is an enormous amount of alumina that may be obtained as a by-product from dawsonite, in oil shale development, however, the recoverable alumina content is not expected to exceed 3% of total oil shale tonnage.

(2) Under current economic conditions, aluminum is in over supply and the cash position of aluminum companies is consequently poor.

(3) The President's cutback and other economic restrictions mitigate against Federal funding for research at this time.

Favorable

(1) There is active White House interest in the NMAB report, presumed to be based on balance of trade deficit and potential defense problems.

(2) The Anaconda Company has offered to donate all research and patent rights to the U. S. Bureau of Mines in return for specific research in areas of needed improvement in their process of producing alumina from kaolin. This could substantially reduce the research costs to the Federal government toward obtaining an economically feasible alumina from kaolin process.

(3) As a result of the July 1, Industry-Interior meeting, Jamaican officials have been to the State Department with inquiries.

A list of attendees at the July 1, 1971, Joint Industry-Interior Aluminum Conference is attached for your information.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:mpc

Enclosure

cc: Mr. Ross Hammond
Dr. John E. Husted
ORA (2)
Mr. Gerald Pitalo
File A-1343

List of Attendees
Joint Industry - Interior Aluminum Meeting
July 1, 1971 - 2:00 p.m.
Department of the Interior Building

Industry

NAME	TITLE	ORGANIZATION	LOCATION (City & State)
Eric A. Walker	Vice Pres. Science & Technology	Alcoa	Pittsburgh, Pa.
Albert B. Kaltwasser	General Manager - Aluminum	Alcoa	Pittsburgh, Pa.
R. S. Smith	Vice Pres. - Administration	National Steel	Pittsburgh, Pa.
C. S. Lohara	Director - Management Services	Eastalco Aluminum	Frederick, Md.
J. S. Apostolina	Vice Pres. & General Manager	Oremet	Hannibal, Ohio
William D. Miller	Director, Manufacturing & Development	Anaconda Aluminum	New York City
Joseph B. Woodlief	President	Anaconda Aluminum	Louisville, Ky.
Jeanice McCoy	Administrative Assistant	Harvey Aluminum	Washington, D. C.
E. L. Phieffer	Plant Superintendent	Intalco Aluminum	Ferndale, Wash.
R. C. Roberts	Vice Pres. - Mining	Reynolds Metals	Richmond, Va.
R. S. Sherwin	Alumina Division Manager	Reynolds Metals	Richmond, Va.
Edd H. Hyde	Vice Pres. - Government Relations	Reynolds Metals	Washington, D. C.
D. J. McPherson	Vice Pres. & Director of Technology	Kaiser Aluminum	Oakland, Calif.
S. L. Goldsmith	Executive Vice President	The Aluminum Assoc.	New York City

Government

NAME	TITLE	ORGANIZATION	LOCATION (City & State)
R. George Crawford	Staff Assistant to the President		Washington, D. C.
H. C. McKittrick	Assistant Chief, Natural Resources Programs Division	OMB	Washington, D. C.
J. David Willson	Budget Examiner	OMB	Washington, D. C.
W. Lawrence	Chief, Stockpile Policy	Off. Emerg. Prep.	Washington, D. C.
C. A. Norred, Jr.	Planning Officer	Off. Emerg. Prep.	Washington, D. C.
Hollis M. Dole	Assistant Secretary--Mineral Resources	Interior	Washington, D. C.
E. F. Osborn	Director	Bureau of Mines	Washington, D. C.
T. A. Henrie	Deputy Director--Mineral Resources and Environmental Development	Bureau of Mines	Washington, D. C.
Paul Zinner	Assistant Director--Planning	Bureau of Mines	Washington, D. C.
Carl Rampacek	Assistant Director--Metallurgy	Bureau of Mines	Washington, D. C.
John E. Shelton	Coordinator for Minerals	OMSF	Washington, D. C.

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

28 September 1971

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During September the project team concentrated on governmental actions which would best support the initial Kaolin to alumina development costs. As reported in the previous monthly report it is considered that three actions, all at the federal level, which would have greatest bearing on an alumina facility being located in Georgia are 1) Federal Subsidization of a pilot plant 2) Low interest government loan for an operating facility 3) Depletion allowance and/or tax credits.

This month interviews with industrial firms have confirmed the proposed actions delineated above would be required before any decision, to commit resources to an alumina facility, can be effected.

Noteworthy are the industrial programs which exist overseas, in that foreign countries are attracting industry by utilizing grants and low cost loans. In turn these industries are competing on the world market for raw materials with U.S. firms. It is believed for economic and strategic reasons the U.S. should offer comparable programs for a domestic source of raw materials thereby allowing U.S. firms to compete sucessfully on the world finished goods market.

In Phase I, Paragraph 2, seven items are listed for review. In accordance with Paragraph 2, the following items have been excluded from primary consideration for economic or political reasons.

1) Government subsidization of a nuclear power plant to produce aluminum. With the processing of Kaolin to alumina uncertain at this time it would be premature to consider this alternative. If an alumina facility can be located in Georgia then the obvious location of an aluminum plant requiring large amounts of electrical energy will make this a viable consideration.

2) Relaxation of oil input quotas. This action is predicated on the utilization of residual fuel oil for the energy requirements of an alumina facility at the calcining step. While the need for fuel for energy is an obvious requirement this action in itself would not stimulate a decision to invest in an alumina facility.

3) Sales tax exemptions. While this may be desirable at the state level, the elimination of sales taxes on energy consumed or any of the other items used in the alumina production process, would not necessarily accure sufficient economies of operations to satisfy its use, without additional incentives at the federal level.

4) Corporate tax credits and tax credits for national defense reasons. Even though Western Hemisphere tax structures are less than those of the U.S. other requirements have higher priorities. Without doubt a tax credit will be necessary but alone such a credit will not induce the committment of any corporation to undertake an alumina venture.

Contacts this month have been with Anaconda, Reynolds, Alcoa, Thiele Kaolin, and Atlanta Gas Light, representing the industrial needs, and with government agencies including White House staff members.

Each has contributed to the study and has brought about the tentative conclusion stated herein.

A significant problem has developed in attempting to quantify the dollar out flows directly related to the import of alumina or bauxite into the U.S. The Aluminum Industry is composed of firms which are fully integrated and control all operations. Consequently the import data which is available is on a value basis and not on a actual cost basis. This makes the quantification of the dollar out flow extremely difficult. Investigation will continue until this problem is resolved.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:vgr

Enclosure

cc: Mr. Ross Hammond
Dr. John E. Husted
ORA (2)
Mr. Gerald Pitalo
File A-1343

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

October 28, 1971

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During the month of October the project team began consolidating information gathered to date in preparation for the Final Report.

Information on special skill requirements and concomitant revenues is being compiled and should be ready for analysis early next month.

The difficulty reported last month in quantifing gold flows attributable to imported raw materials (bauxite and alumina) has been resolved. Interviews with Professionals of the Department of Interior, Bureau of Mines, Treasury Department and U.S. Customs provided the necessary inputs and methods to make determinations necessary to quantify gold flows.

For 1968, alumina imports amounted to 1.4 million short tons at approximately $60/ton valuation for a total value of $84 million. Discounting the value 20%-25% gives a $48-$45 per ton cost which agrees with data published by the NMAB. Total cost ranges between $63-$67 million.

Bauxite imported in 1968 amounted to 11 million short tons valued at $140 million or $14 per ton. Depending on what processing is performed on the bauxite this value can be discounted 50% to 25% to reflect actual costs. Therefore $70 to $100 million can be attributed to imported bauxite.

Total flows attributable to both imported bauxite and alumina for 1968 range between $133-$167 million, a considerable sum of money. It is not considered unrealistic to assume a growth in these figures through 1985 which would cause an increase to in excess of $200 million. This part of the analysis is not yet complete but should be ready by mid November.

Another area of concern which will need action is the matter of transportation of alumina and raw materials to and from the Kaolin belt. Attached is a schedule of clay rates which are projected as being comperable to possible alumina rates.

Also attached is a rough draft of the impact of the proposed alumina project on the Kaolin Industry.

The project team requests guidance on final report format. To obviate difficulties later possible end uses of this report need to be studied and a format devised to best utilize the information generated. A meeting will be scheduled in early November to discuss this matter.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:vgr

Enclosures

cc: Mr. Ross Hammond
Dr. John E. Husted
ORA (2)
Mr. Gerald Pitalo
File A-1343

"An Analysis of the Impact of the Proposed Project Upon the Current Kaolin Industry and what the Future Implications would be for such a Development."

by

John E. Husted

The estimated impact of an alumina (Al_2O_3) from Kaolin Industry must be predicted upon the size of the new industry. The principal guides to size are: (1) a minimum size kaolin to alumina plant of 1,000 tons* of alumina per day as shown in the NMAB Report 278, Processes for Extracting Alumina from Non-Bauxite Ores (1970), and (2) the present and predicted use of aluminum in the United States to obtain an estimated maximum United States alumina requirement.

A smaller alumina from kaolin plant, of perhaps half the tonnage that is mentioned in the NMAB Report, has been suggested by an industry source but the relative economics have not been established.

For purposes of estimating, a 30% recovery of alumina from kaolin (averaging 35% Al_2O_3) and a 2:1 alumina to aluminum recovery has been used. Actual aluminum from alumina is 52.9% instead of 50% but the alumina from kaolin can only be estimated at present.

Based on a 350 day working year, a 1,000 ton* per day alumina plant would produce 350,000 tons* of alumina and consume 1,166,666* tons of kaolin in a year. This is roughly one third of the 1970 Georgia kaolin production. Obviously, a 500 ton per day alumina plant would not require but half this amount of kaolin.

*2,000 lb. tons

If one uses the lower NMAB projected figure of 9 million tons* per year domestic demand for primary aluminum in 1985 and also project that say 85% of this demand would be met by domestic kaolin, then the annual kaolin requirement would be 51 million tons*, or 13 to 14 times 1970 annual Georgia kaolin production, or 18 times if the larger figure of 12 million tons* is used. In this same time period (1970-1985), however, kaolin production for present uses is predicted to rise 2 to 3 times 1970 production, or between 9 and 12 million tons.*

Based on the above, there clearly emerges several tangible possibilities regarding the impact on the kaolin industry by an alumina from kaolin industry.

1. Based on predictions of increased demand for kaolin, there should be much greater competition for reserves. If, as the kaolin industry states, reserves are for the most part under 99 year leases by kaolin companies, then that competition could take place more at the corporate level rather than the land owners' level. This could escalate prices but obviously not to the extent of pricing out of the market. More probable would be joint ventures between kaolin companies and aluminum companies.

2. There should be an impact on the labor market. Several possibilities arise. First, there would be a change to union labor (the Georgia kaolin industry in non-union now); second, a temporary skilled manpower shortage could develop, coupled with an increase in cost of labor; but third, there should be, in the long run, a more stable labor force.

3. The demands of the aluminum industry would put a premium on large deposits of kaolin that could be readily mined in close proximity to the processing plant. Since the aluminum industry would already be fighting bauxite

competition, mining costs would need be low. Selective mining and selective transportation would probably not be economically permissible. This, in turn, would require protection of the high value clays for present uses such as for paper. A question arises concerning reserves for each. The impact here would be to stimulate better knowledge of the reserves through research. This would also be required for better planning.

4. There should be an impact on the tax digest that should help the kaolin companies.

5. Required new power, transportation and other supply sources could benefit the present kaolin industry.

6. If it permitted disposal of large tonnage reserves of clay of questionable use for present kaolin markets, the impact on the kaolin companies would be in their favor and put them in a much better capital position for research and expansion.

All of the above will be proportional to the size and growth of an alumina from kaolin industry.

CLAY RATES

FROM: SANDERSVILLE, GA.

DESTINATION	MILES	MILEAGE BLOCK	RATE PER TON
Savannah, Ga.	139	100	$ 3.57
Valdosta, Ga.	202	200	4.59
Canton, N. C.	288	300	6.75
Kingsport, Tenn.	403	400	10.09
Jackson, Tenn.	519	500	10.73
Hamilton, Ohio	620	600	11.59
Chillicothe, Ohio	705	700	12.87
Luke, Md.	782	800	14.11
Louisville, Ky.		600	11.37

190,000 LB. MINIMUM

A-1343

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

November 29, 1971

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During the month of November the project team concentrated on the following activities:

1. Final report format
2. Additional information on process cost
3. Manpower requirements and accrued revenues
4. Evaluation of satellite industries

On November 3, 1971 the project team met with Col. Harold Dye and Mr. Jim Bohanan to obtain direction pursuant to the format of the final report. The use of the report was discussed and a general approach to format style was agreed upon at that time.

On November 8, 1971 the project team submitted a topical outline of the suggested format for the camera-ready copy of the written report. It is requested that any modifications and/or approval of the suggested format be given the project team at your earliest convenience.

It is our understanding that the report will consist of 3 main parts broken down into several documents. The first document will contain the first two parts and will be categorized as a narrative report and a technical report. The technical report will appear as an Appendix to the narrative report. The third part will contain information pertenant to accomplishing the various recommendations in the published report. Style will consist of informal letter format.

Additional process information was obtained this month. From this information the cost structure and manpower requirements for a nitric acid process have been identified. It appears that through technical innovation and automation the cost of alumina derived from clay can be produced at an estimated cost of $50 per ton. This cost does not include any tax credits, depletion allowance or extraordinary incentives. At this cost the nitric acid/clay process shows considerable promise as a substitute for the Bayer/bauxite process.

Manpower requirements indicate that a staff of approximately 225 people will be required to manage, operate, and maintain a 1000 tpd (tons per day) plant. The mining operation will require additional operating and supervisory personnel and are not included in the above head count.

In the near future it is not anticipated that a satellite industry will be created as a direct result of establishing a 1000 tpd plant. However should 3 or 4 plants be established later, it is possible that an acid producing facility would be economically feasible. A service industry will be created as there will be significant maintenance required for this highly corrosive process. Materials, spare parts, transportation of maintenance materials, facility grounds maintenance will all have a direct influence on state and local service industries.

To date we have received no information on the results of research done by the Georgia Department of Mines, Mining and Geology. It is requested that the project team be furnished an interim report of the findings of the Georgia Department of Mines, Mining and Geology so that we may consider these findings in our continuing research.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:vgr

Enclosures

cc: Mr. Ross Hammond
Dr. John E. Husted
ORA (2)
Mr. Gerald Pitalo
File A-1343

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

December 29, 1971

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

On November 8, 1971 the project team submitted a topical outline of the suggested format for the camera-ready copy of the written report. On November 29, 1971 in the monthly progress report we requested that any modifications and/or approval of the suggested format be given the project team at your earliest convenience. To date we have received no indication of desired modifications. Accordingly, we are proceeding on the assumption that the suggested format for the report is approved.

To date we have received no information on the results of research done by the Georgia Department of Mines, Mining and Geology. It is requested that the project team be furnished a report of the findings of the Georgia Department of Mines, Mining and Geology so that we may consider these findings in our continuing research.

In the month of December the project team has concentrated on refining data for the final report. To date rough drafts have been completed on five appendices (Technical Report). The remaining appendices and the narrative portion of the report will be started in January.

The following list delineates activities which each appendix will consider:

Appendix	Title
A	GOLDFLOW MEASUREMENT AND PROJECTIONS Demand and supply for the U.S. and the world, goldflow attributable to imported raw materials, and tax projections of annual goldflow with associated tax and interest losses.
B	ECONOMIC COMPARISONS JAMACIAN BAUXITE AND KAOLIN Mining costs and effects of depletion allowances.
C	PROCESS COST AND RESEARCH REQUIRED Updated process cost with projections of future increases in productivity and decreases in cost.
D	IMPACT OF THE PROPOSED PROJECT UPON THE KAOLIN INDUSTRY Competition for reserves, labor market impact, selective vs. nonselective mining, impact on the tax digest, utilization of present Kaolin of undersired paper grade quality.
E	ESTIMATES OF STATE INCOME, EMPLOYMENT AND REVENUES Based on manpower projections payrolls and their probable effects are discussed.
F	EVALUATION OF SATELLITE AND SERVICE INDUSTRIES The direct results of an alumina plant with respect to a satellite industry and the indirect results such as housing, retail trade, services are discussed.
G	EFFECT ON TRANSPORTATION SYSTEMS Probable effects on rivers, railroads and highways immediately and in the future.
H	RECOMMENDATION Listing of government actions required to establish an Alumina Industry in Georgia utilizing Kaolin.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:vgr

Enclosures

cc: Mr. Ross Hammond
Dr. John E. Husted
ORA (2)
Mr. Gerald Pitalo
File A-1343

A-1343

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

January 28, 1972

Georgia Department of Industry and Trade
Trinity-Washington Building
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No.A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During the month of January the project team has continued to concentrate on refining data for the final report. Rough drafts on all appendices have either been completed or started. Work on the narrative portion of the report has been started. It is expected that as the work progresses gaps in information will be found which will necessitate recontacting the original data source for the missing information.

It is hoped that the results of research done by the Georgia Department of Mines, Mining and Geology will be available to the project team during the month of February.

The project team shall contact the Georgia Department of Industry and Trade during the month of February to discuss two major points which, to date, have not been explored in detail. These are: 1) the development of a positive public information program for dissemination to national, state, and local audiences; and 2) a step-by-step listing of priorities that are necessary in order to maximize the effort in seeking the solutions that will make the production of Georgia kaolin feasible as a source of alumina.

There was a change in the make up of the project team during the month of January due to the resignation of Mr. Gerald A. Pitalo. Mr. Pitalo has been replaced on the project team by Mr. Philip D. Koos, Jr.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:ms

cc: Mr. Ross Hammond
Dr. John E. Husted
ORA (2)
Mr. Philip D. Koos, Jr.
File A-1343

A-1343

ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE of TECHNOLOGY

ıstrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

March 29, 1972

Georgia Department of Industry and Trade
Trinity-Washington Building
P. O. Box 38097
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Progress report on Industrial Development Research Project No. A-1343, "A Study to Analyze the Alumina from Kaolin Potentials"

Gentlemen:

In accordance with Paragraph 7 of Project No. A-1343 Agreement, the following progress report is submitted.

During the month of March the project team refined the data for the final report. A draft of the report has been completed. Conclusions and recommendations and elements of the report were discussed with aluminum industry representatives, kaolin industry representatives, and U. S. Bureau of Mines representatives.

Information was furnished to Mr. James O. Bohanan, to be used in reply to a letter from Mr. Ode, Coastal Plains Regional Commission.

The project team has not been back in contact with Mr. Ed Spivia, Public Information Officer, Georgia Department of Industry and Trade. This needs to be the first order of business in April so that the development of the public information program for dissemination to national, state and local audiences may be accomplished.

A brief summary of the report follows:

1. If bauxite should continue to be the sole source of aluminum for the United States, then by 1980 we will need to import 95 percent of our primary aluminum needs and even more in succeeding years. Aluminum, as now produced in the free world, still uses (with modifications and improvements) the Hall-Heroult aluminum reduction process of 1886 and the Bayer-bauxite process of 1888 for making alumina because they are still the most economic means to meet aluminum demand.

Raw materials that have been investigated in the United States are summarized in the National Materials Advisory Board Report 278. Favored, and recommended for an integrated pilot plant operation is a nitric acid leaching of kaolin to produce alumina. Present information indicates this to be competitive with the Bayer-bauxite process. Reserves of kaolin are more than adequate.

2. Balances of trade minimum projections, based on importation of bauxite and alumina indicate out-flow of United States dollars will be in the amount of $294,000,000 for 1972 and rising annually to $835,000,000 for 1985. This is a minimum dollar estimate that does not allow for increased nationalization by source countries, which could increase this by perhaps 10 to 40 fold.

3. An alumina from kaolin industry, would take 6 to 8 years, under normal procedures, to advance from a 5 ton per day pilot plant to a 50 ton per day pilot plant to a 1,000 ton per day first generation commercial plants. Hence, under normal procedures, tonnage and dollar impact would not be expected until after 1980 if pilot plants begin in 1973. The extent to which this will be accelerated is not known, as neither a starting date of a pilot plant nor the number of first generation commercial plants and their timing can be predicted at this point. Presidential executive action could probably move the starting time up to sometime this calendar year (1972).

An immediate and continuing favorable impact on trade negotiations is expected from a first pilot plant effort.

4. A first generation commercial plant of 1,000 tons per day is expected to employ directly in excess of 250 skilled or semi-skilled persons, with an indirect increase of 1,000 persons.

Revenue impact in taxes is expected to be on an order of 650 thousand dollars as based on a 50 million dollar plus investment and the number of new jobs for each first commercial plant of 1,000 tons per day.

5. The initial impact on the kaolin industry will be the move to secure kaolin reserves by the aluminum industry. A serious production impact is not anticipated until second generation commercial plants come on stream. In general, excepting possible by-product silica competition in the filler and pigment markets, the impact should be favorable as much clay not currently useable will be acceptable to the aluminum industry.

6. Sattelite industries using alumina could add to the industrial growth of the area. Supply industries and transportation are not expected to be greatly affected until second generation plants are in operation.

7. Research is needed in the form of integrated pilot plants to give a substantial technical and economic base for scaling up to commercial plants. Lowest cost per ton of alumina from kaolin as now projected is $53, without the recommended depletion as compared to $48 current Bayer-bauxite processing. With the recommended depletion, cost is $41 per ton of alumina. This needs confirmation by integrated pilot plants.

In addition the pilot plants are needed to find working solutions to environmental problems.

Projected is a first 5 ton per day nitric acid process kaolin to alumina pilot plant. Based on data from this plant a 50 ton per day pilot is projected to be probably followed with 1,000 ton per day first generation commercial plant(s). The 1,000 tons per day commercial plants are expected to be experimental plants.

The 5 ton per day pilot plant is projected to take from 3 to 4 years with a total cost not to exceed $20 million or more than $8 million in any one year for both operating and capital costs.

8. Some of the environmental considerations to be investigated are: hydrological impact, control of fumes, and control of effluent materials. These are also part of the pilot plant operation.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:mas

CC: Mr. Ross W. Hammond
Dr. John E. Husted
ORA (2)
File A-1343

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE of TECHNOLOGY

Industrial Development Division

1132 W. Peachtree Street
Atlanta, Georgia 30309
873-2931 Area Code 404

A-1343

April 20, 1972

Georgia Department of Industry and Trade
Trinity-Washington Building
P. O. Box 38097
Atlanta, Georgia 30334

Attention: Mr. James O. Bohanan

Subject: Alumina from kaolin implementation

Gentlemen:

In accordance with Paragraph IV, Phase III, of Project A-1343 Addendum, it is suggested that the following steps be taken to implement the recommendation for establishment of a 5-ton-per-day integrated pilot plant for the purpose of definitive research directed toward obtaining the best economic and technical method(s) for obtaining alumina from domestic sources of kaolin clay.

1. Discuss the project with and provide information to those Federal Government Agencies to be involved in establishment of a pilot plant.

2. Discuss the project with and secure active support from:

   a. The Coastal Plains Regional Commission
   b. Companies in the aluminum industry.
   c. Companies in the kaolin industry.
   d. High State of Georgia officials
   e. Members of the Georgia General Assembly.
   f. Georgia Congressional delegation.

3. Secure introduction of federal legislation to provide necessary funding for establishment and operation of pilot plant.

4. Discuss the project with and request the Office of Management and Budget, Executive Office of the President, to provide for Federal funds in the budget for alumina research and development.

5. Be prepared to testify at committee hearings relating to legislative and budget matters concerning the project.

6. Secure support from the public through a positive public information program.

It is considered that the Georgia Department of Industry and Trade should have the primary responsibility for implementing the above steps and the current project team, under contract to the Georgia Department of Industry and Trade should coordinate and expedite the action required.

If the integrated pilot plant proves technical feasibility and economic justification then implementation of additional recommendations should be undertaken.

If there are any questions or additional information is desired, please give me a call.

Sincerely,

William C. Ward, Jr.
Head, Special Projects Branch

WCW:mas

cc: Mr. Ross W. Hammond
Dr. John E. Husted
ORA (2)
File A-1343

Project A-1343

ALUMINA FROM KAOLIN POTENTIALS

Prepared for
Georgia Department of Industry and Trade

by
William C. Ward, Jr.
Dr. John E. Husted
William C. Howard
Amy Collins

Industrial Development Division
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
April 1972

Table of Contents

Acknowledgments

Many people and organizations have been consulted during the course of this investigation and each has assisted with very helpful input of information and critical reviews and discussions. We gratefully acknowledge each of them as follows:

Aluminum Companies

Aluminum Company of America
Amax Aluminum Company
Anaconda Aluminum Company
Kaiser Aluminum and Chemical Corporation
Reynolds Metals Company
National-Southwire Company
The Aluminum Association

Kaolin Companies

Engelhard Minerals and Chemicals Corporation
Freeport Minerals Company
Georgia Kaolin Company
J. M. Huber Corporation
Thiele Kaolin Company

Other Non-Government

R. W. Hyde of Arthur D. Little, Inc.
Sandersville Railroad Company

Federal Government

The Interior Department
    U. S. Bureau of Mines

The Georgia Delegation to the United States Congress

State Government

Various State of Georgia Agencies

This report has been the responsibility of the Industrial Development Division of the Engineering Experiment Station at the Georgia Institute of Technology (Georgia Tech).

The need for this study was mutually recognized and discussed by Col. Harold Dye of the Georgia Department of Industry and Trade, the late Dr. George I. Whitlatch of the Industrial Development Division, and Dr. John E. Husted of the Engineering Experiment Station's Technology Applications Group. As a result of these discussions, an alumina-from-kaolin seminar, co-sponsored by the Georgia Department of Industry and Trade and the Georgia Institute of Technology, was held in Atlanta in September 1970. The National-Southwire Company was the host for the seminar. Attendance was by invitation only, and attendees were key representatives of the aluminum and kaolin industries and government agencies. The issuance of the NMAB Report 278, "Processes for Extracting Alumina from Nonbauxite Ores," in December 1970 is regarded as having been at least partially spurred by this meeting. Subsequently, the Georgia Department of Industry and Trade secured funding from the Coastal Plains Regional Commission which it in turn subcontracted with Georgia Tech for the study reported herein.

The principal author of this report is Dr. John E. Husted. William C. Howard is mainly responsible for Chapter 6. Mrs. Amy Collins was most helpful in the analysis of statistical data in Chapter 3. William C. Ward, Jr., the Project Director, was responsible for the overall project and coordinated the efforts of the project team.

Summary

The following summary is to show pertinent information or objectives by chapters. Detail for numbered statements may be found in the chapters of the same number.

1. The United States aluminum industry has grown from less than 500 pounds of primary aluminum supply in 1885 to approximately 3.9 million short tons of capacity of primary aluminum and an estimated total consumption of aluminum of 5.38 million tons in 1969. Domestic scrap recovery in 1969 raised total United States aluminum supply to 4.82 million tons, which was still less than consumption. Average growth rate projections are between 5.1% to 7.4% per year or between 21.2 and 42.0 million short tons of consumption by the year 2000 for the United States. The free-world growth has been projected at an annual rate of 5%.

2. If bauxite should continue to be the sole source of aluminum, the United States by 1980 will need to import 95% of its primary aluminum needs and even more in succeeding years. Aluminum producers in the free world still use (with modifications and improvements) the Hall-Heroult aluminum reduction process of 1886 and the Bayer-bauxite process of 1888 for making alumina because they are still the most economic means to meet aluminum demand.

Raw materials that have been investigated in the United States are summarized in the National Materials Advisory Board Report 278. Favored, and recommended for an integrated pilot plant operation, is a nitric acid leaching of kaolin to produce alumina. Present information indicates this to be within competitive range of the Bayer-bauxite process. Reserves of kaolin are more than adequate.

3. Balances of trade minimum projections, based on importation of bauxite and alumina, indicate outflow of United States dollars will be in the amount of \$294 million for 1972 and rising annually to \$835 million for 1985. This is a minimum dollar estimate that does not allow for increased nationalization by source countries, which could increase this by perhaps 10 to 40 fold.

4. Research is needed in the form of integrated pilot plants to give a substantial technical and economic base for scaling up to commercial plants. Lowest cost per ton of alumina from kaolin as now projected, based on 1972 costs, is approximately \$62, without the recommended depletion, as compared

with a reported \$48 for current Bayer-bauxite processing. With the recommended depletion, cost per ton of alumina from kaolin would be approximately \$48. This needs confirmation by integrated pilot plants. In addition, the pilot plants are needed to find working solutions to environmental problems.

Projected is a first 5-ton-per-day nitric acid process kaolin-to-alumina pilot plant. Based on data from this plant a 50-ton-per-day pilot is projected, to be followed probably with 1,000-ton-per-day first generation commercial plant(s). The 1,000-ton-per-day commercial plants are expected to be experimental plants.

The 5-ton-per-day pilot plant is projected to take from three to four years, with a total cost not to exceed \$20 million or no more than \$8 million in any one year for both operating and capital costs. Cost of a 50-ton-per-day pilot plant will need to be determined from operating data derived from the 5-ton-per-day plant.

5. An alumina-from-kaolin industry would take six to eight years, under normal procedures, to advance from a 5-ton-per-day pilot plant to a 50-ton-per-day pilot plant to a 1,000-ton-per-day first generation commercial plant. Hence, under normal procedures, tonnage and dollar impact would not be expected until after 1980 if pilot plants begin in 1973. The extent to which this can be accelerated is not known, since neither a starting date for a pilot plant nor the number of first generation commercial plants and their timing can be predicted at this point. Presidential executive action could probably move the starting time up to sometime this calendar year (1972).

An immediate and continuing favorable impact on trade negotiations is expected from a first pilot plant effort.

6. A nitric acid commercial kaolin-to-alumina plant of 1,000 tons of alumina per day is expected to employ in excess of 250 skilled or semiskilled persons directly, with an indirect employment increase of 1,000 persons for services, trade, education, etc.

Revenue impact in taxes is expected to be on the order of \$650 thousand as based on a \$50 million plus investment and the number of new jobs for each first commercial plant of 1,000 tons per day.

7. The initial impact on the kaolin industry is expected to be the move to secure kaolin reserves by the aluminum industry. A serious production impact is not anticipated until second generation commercial plants come on stream. In general, excepting possible by-product silica competition in the filler and pigment markets, the impact should be favorable since much clay not currently usable will be acceptable to the aluminum industry.

8. Satellite industries using alumina could add to the industrial growth of the area. Supply industries and transportation are not expected to be greatly affected until second generation plants are in operation.

9. Some of the environmental considerations to be investigated are hydrological impact, control of fumes, and control of effluent materials. These determinations are also objectives of the pilot plant operation.

CONCLUSIONS AND RECOMMENDATIONS

A review of the use of bauxite as the only primary source of alumina and aluminum has revealed that the United States is in a vulnerable, if not dangerous, position concerning supplies of this important metal. Current domestic supplies are on an order of 11% of annual need and are projected to be 5% by 1980 and less by 1985. The nation's vulnerability is in at least three areas:

1. Supplies for the domestic aluminum industry constitute a dollar outflow of approximately $294 million currently, with a projected annual outflow of approximately $835 million by 1985 if bauxite is continued as the only source of alumina and aluminum. This could be increased approximately fourfold if nationalization of present sources requires all bauxite to be converted to alumina before shipment and possibly forty-fold if it must be converted to aluminum.

2. The current and projected dependence of the United States on foreign bauxite for alumina and aluminum has deteriorated the nation's negotiating position on the international market. Further, it has and will subject the U. S. to increasing economic pressures. This could take the form of full expropriations, as was the case of copper in Chile, or encroachment of management and profits. Pressures probably will mount to produce more alumina, aluminum, and aluminum products in foreign countries, which would further erode the United States' trade deficit position as noted in paragraph 1 above.

3. In addition to the above economic and political vulnerabilities, the United States is and will continue to be in the dangerous position of strategic logistical exposure as foreign bauxite and alumina move to this country by water. Despite national stockpiles, this is still true as has been developed in Chapter 5 of this report.

The present problem, however, is not that the United States actually lacks adequate sources of aluminum-bearing minerals. The problem has been the economic advantage of the technology of using bauxite versus the economics of technologies of other aluminum-bearing minerals. Until about 10 years ago there also may have been some questions of domestic reserves. During the immediate past decade, however, enormous domestic reserves of kaolin have been discovered, and research by the U. S. Bureau of Mines and by industry has brought kaolin to what appears to be a competitive position with bauxite.

The question is what is to be done and how to proceed in implementing an economically competitive, self-sufficient domestic alumina-aluminum supply. The action recommended in this report is directed toward giving answers to this question.

Federal Government

Direct Financial Action

1. It is recommended that direct full funding be allocated to be used or administered by the Bureau of Mines, United States Department of the Interior, in cooperation with industry, for the purpose of definitive research directed toward obtaining the best economic and technical method(s) for obtaining alumina from domestic sources in large supply. On the basis of present information, it is recommended that a nitric acid process for clay, using the best available knowledge, be tested in a 5-ton-per-day integrated pilot plant to determine if operational technology and estimated cost of operation are correct and may be scaled to a larger plant. Recommended is an allocation total of $20 million for four years, not to exceed $8 million in any one year for a 5-ton-per-day pilot plant.

If the 5-ton-per-day pilot plant proves technical feasibility and economic justification, it is recommended that direct full funding be allocated for a 50-ton-per-day pilot plant, with administration through the U. S. Bureau of Mines continued. Cost of this funding will have to be determined after data are available from the 5-ton-per-day pilot plant. Unit costs are expected to be much lower.

In addition, such a pilot operation should provide methods of solving legal and technical problems that could arise concerning the environmental impact of mining and processing.

2. It is recommended that low-cost loans, appropriately funded, be made available or guaranteed by the federal government for construction of at least the first commercial plants operated by private industry for the production of alumina from domestic kaolin.

Rationale of Direct Financial Action

Consensus of aluminum industry representatives interviewed during the course of this study is that later generations of plants using kaolin as a source of alumina would have a decided economic competitive advantage over earlier experimental plants. This is expected to be true both because of technological improvements that could be used in the new plants and because of economies that could be effected by larger scale plants.

Such advantages would place an unfair economic burden on those companies whose risk capital was tied up in experimental models, whereas companies not so burdened could proceed with investments based on better technology. It is concluded, therefore, that the federal government, to protect its own interest, would be justified in supplying the risk capital to effect technological improvements projected as results from experimental or pilot plants and needed for the competitive production of alumina from domestic kaolin. On the other hand, no company can justify use of its risk capital for the benefit of its competitors.

Tax Relief Action

1. It is recommended that legislative action be taken that will permit depletion allowances for clay (kaolin) and other domestic minerals to include as mining costs all processing steps through the production of alumina, when used as a primary ore of aluminum. This should be an amendment to Title 26, Section 613, c, 4, of the Internal Revenue Code.

Under 613 (c) Definition of Gross Income from Property, (4) of the Internal Revenue Code, the following should be added:

> In the case of clay (kaolin), laterite (including bauxite), anorthosite, alunite, and nephelite syenite extracted from deposits in the United States, all processes applied to derive an aluminum compound, such as alumina, as the process steps immediately preceding production of aluminum, shall be considered as mining.

2. It is recommended that investment credit be given against taxes, consistent with federal investment credit practice, for capital investments in pilot or regular plant construction of a facility to produce alumina from kaolin.

Rationale for Tax Relief Action

1. Ores of metals customarily have the percentage allowance for depletion applied against process costs in bringing ore to a step that is usually immediately prior to the production of usable metal. As examples, blister copper is used for copper, cyanidation for gold, etc.: Internal Revenue Code (613) (c) (4) (D). It seems illogical to permit other metals to reach a process stage, such as with one-half of one percent copper ore to blister copper, and not allow the same for kaolin to alumina.

2. Investment credit seems to be a useful means of lowering some of the financial risk through tax relief in order to start a new domestic industry which promises so much strategic and financial relief to the nation. It is important in the initial stages of development to offset present operating economies accruing to the use of foreign bauxite and to accelerate plant construction.

Other Federal Action

1. It is recommended that, to the extent feasible, rail rates for the transportation of domestic alumina from kaolin to reducing plants be made competitive with water rates for alumina derived from foreign sources to the same plants.

2. It is recommended that legislative action be taken to assist secondary or spin-off industries of alumina production in rural areas. Such legislative action would be in line with reversing the trend of migration from rural to urban areas.

State and Local Government

Tax Relief

1. It is recommended that sales tax on utilities be exempted, since it is anticipated that commercial alumina plants will be large consumers of fuel, electricity, and other utilities. This would assist in making utilities more competitive with other regions of the nation who have very low utility rates.

2. It is recommended that a thorough study be made by appropriate taxing bodies of other possible tax relief. The advantages of encouraging a new

industry should be carefully weighed against the costs of services that state or local governments would need to furnish and pay for.

3. Assessments for taxes of the new industry should be as equitable as possible.

Other Action

1. The General Assembly of Georgia should pass resolutions requesting the Georgia delegation to the Federal Congress to support the foregoing recommendations.

2. The Governor of Georgia and other high officials should make known publicly their encouragement to establish this new industry and the recommended action to implement it.

3. The General Assembly of Georgia should work with industry to secure equitable and workable regulations concerning environmental/ecological controls. A balance must be achieved that protects the public without eliminating industry.

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Chapter 1

BACKGROUND OF THE ALUMINUM INDUSTRY

Historical Development

Sir Humphry Davy designated the metal of the oxide alumina as "alumium" in 1808 and later changed it to "aluminum." In many countries the spelling was later changed to "aluminium." Bauxite was discovered in France in 1821. Hans Christian Oersted produced the first elemental aluminum in 1825. Henri Sc. Claire Deville, using chemical reduction in batch procedures, produced the first commercial aluminum in 1854 in France. Prices in 1857 and 1859 were $27 and $17 per pound, respectively.

In 1884 the first American bauxite was discovered near Rome, Georgia. In 1885 less than 500 pounds of aluminum were produced in the United States from foreign ore. In 1886 Charles Martin Hall in the United States and Paul Heroult in France independently discovered the continuous electrolytic process, which basically is the process still used for producing the metal aluminum from alumina. In 1888 Karl Bayer invented the current commercial process for producing alumina from bauxite. In 1889, 728 tons of bauxite were mined near Rome, Georgia, being the first United States production. In 1899 the first Arkansas bauxite was mined in the amount of 5,045 tons. Until World War I more than 95% of the bauxite produced came from mines in the United States and France. Mines in British Guiana started shipment in 1917 and Surinam in 1922. Bauxite production began in Russia in the late 1920's.

The Aluminum Industry in the United States

The Aluminum Company of America (Alcoa) was the only United States producer of primary aluminum from 1886 until 1940. World War II needs required much larger amounts of aluminum and gave impetus to new production facilities. Reynolds Metals Company began production in 1941. Kaiser Aluminum and Chemical Corporation purchased surplus World War II plants and entered production in 1946. Anaconda Aluminum Corporation's first production was in 1954 and that of Ormet Corporation and Harvey Aluminum, Incorporated, each in 1958. A Swiss-owned company, Consolidated Aluminum Corporation (Conalco), began United States production in 1963; Intalco Aluminum Corporation, in 1966; National-Southwire Aluminum Company, in 1969; and Eastalco, a Howmet-Pechiney subsidiary, in 1970. Although refinements and improvements have taken place, 1972 aluminum production still results from the Hall-Heroult reduction process of 1886 and the Bayer bauxite-to-alumina process of 1888.

Aluminum Consumption and Capacity

Beginning in 1954, primary aluminum became first in nonferrous metal production and second to ferrous metal in the metal production of the United States. Estimated growth rate, with obviously some fluctuations, is pegged to population increases and resulting increases in construction and consumer products. N. V. Davis, President of Alcan Aluminum, Ltd., projects free-world consumption to grow at an annual rate of 5% instead of the 8% of the past decade and as compared with the U. S. Bureau of Mines projection of 5.1% to 7.4% for the United States. (Ref. 1.)

Excluding national defense stockpiles, supplies of aluminum to the United States from all sources, including scrap, rose from 0.9 million tons in 1949 to 5.38 million tons in 1969. (Ref. 2.) This supply included 3.79 million tons of domestic primary production and recovery of 1.03 million tons of domestic scrap, or 4.82 million tons of domestic aluminum supply in 1969. In the more recent past, the upward movement of consumption of aluminum with corresponding supply has continued.

The U. S. Bureau of Mines showed 1968 demand at 4.31 million tons, with projected demand between 21.2 and 42.0 million tons in the year 2000. (Ref. 3.) I. Lipkowitz estimated United States consumption of aluminum to have been 4.56 million tons in 1968, 4.906 million tons in 1969, 4.475 million tons in 1970, and 4.866 million tons in 1971. (Ref. 4.) This reflects the 1970 economic decline but shows an up-turn in 1971. Obviously there will be annual fluctuations, up and down, from average projections, but the trend is up.

United States primary aluminum capacity in 1969, as shown in the Aluminum Association's annual statistical review for that year, was 3.9 million short tons. (Ref. 2.)

With capacity of primary aluminum at 3.9 million short tons, current consumption at 4.5 to 4.9 million short tons, and projected consumption or demand between 21.2 and 42.0 million short tons by the year 2000, the need for new capacity in the United States is obvious.

Aluminum consumption and capacity has been growing in the rest of the world also. Countries in the European Common Market with mature economies probably will be a strong source of competition both for sales and supplies. Many less developed countries with raw material sources of alumina likely will continue to insist on integrating aluminum production at least to the metal and possibly to products as part of nationalization.

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Chapter 2

ALUMINUM SUPPLIES AND TECHNOLOGIES

Present Bauxite Ore Sources

Bauxite is the only ore of aluminum used at present for commercial production of aluminum in the free world. Bauxite is a heterogenous mixture of impure hydrous aluminum oxide minerals. The principal minerals are gibbsite, $Al(OH)_3$; boehmite, AlO(OH); and diaspore, AlO(OH). Major impurities are iron and titanium oxides and aluminum silicates. The relative amounts of these minerals and impurities vary from deposit to deposit.

Bauxite was formed by a lateritic weathering process in which iron and aluminum silicates were decomposed, and silica (along with many other elements) were removed by natural leaching. This resulted in a concentration of iron, aluminum, and other remaining hydrous oxides (usually surface or near surface). In general, laterization is favored by humid tropical climates and relatively flat-lying material.

Because bauxite deposits are found frequently at the surface or near surface, open-pit mining methods and large equipment are usually used, which in turn makes for lower unit costs for the mined material.

The latest available production and import figures from the U. S. Bureau of Mines' Minerals Yearbook for bauxite and alumina were for 1969. (Ref. 5.) In that year the United States produced 1,843,000 long tons of bauxite, as compared with 12,180,000 long tons of imported bauxite. Of domestic bauxite, 95% came from Arkansas. The imported bauxite was approximately 87% of total imported and domestically produced bauxite. The domestic bauxite was valued at $25,725,000 and the imported bauxite at $165,802,000.

In 1969 the United States also imported 1,912,000 short tons of alumina valued at $106,333,000. This, with bauxite imports, constituted $272,135,000 for imported raw materials for aluminum for 1969.

The 1969 imported bauxite was derived as follows: 59% from Jamaica, 23% from Surinam, 8% from the Dominican Republic, and the remaining 10% from Haiti, Venezuela, and Guyana.

Australia furnished 69% of the imported alumina, with Surinam and Jamaica supplying most of the remainder.

Future Sources Based on Present Production Technology

The U. S. Bureau of Mines indicated in 1970 that annual production of domestic bauxite would continue at about 400,000 tons (aluminum content) per year until the year 2000. (Ref. 3.) There was estimated to be an aluminum content reserve of 12,800,000 tons. Approximately 55 million tons of aluminum content were believed to be recoverable from domestic low-grade bauxite ores that are not economically feasible at present. The world reserve of bauxite on an aluminum content basis was set at 1.2 billion tons in 1969, but it is probably at least 2 billion by now (1972) because of new discoveries.

The aluminum content of domestic bauxite met only 11% of the demand in 1968, with an average of 13% for the period 1965-1969, a projection of 8% for 1970-1975, and only 5% in 1980. (Ref. 6, p. 12.) Within eight years it is projected that 95% of the United States' requirements for primary aluminum will be imported, if present trends continue.

All of this will move by water transportation from foreign sources. With the growing trend of many nations toward nationalization, the probability is that much of this country's aluminum requirement of the future will be shipped as alumina or aluminum ingots or products. Economics of transport and technology favor alumina since shipping costs are about the same as for bauxite and the production facilities are less demanding than those required in producing the metal.

Technology of Production of Aluminum from Bauxite

As stated previously, most bauxite deposits lend themselves to low-unit-cost mining by open-pit methods.

The current processing of bauxite to produce alumina is by the Bayer method or some variation of it. The Bayer process was patented in 1888 in Germany. The Bayer process consists essentially of a caustic leach of bauxite at high temperatures and pressures. Differences between the American and European Bayer processes are that the American process uses less caustic, lower temperatures, and lower pressures. (Ref. 7.) The resulting sodium aluminate solution is separated, followed by selective precipitation of a relatively pure hydrated aluminum oxide ($Al_2O_3 \cdot 3H_2O$). This material is filtered, washed, and then calcined. The calcined product is the furnace feed in making aluminum.

Primary aluminum is produced by the electrolysis of alumina in a molten bath of cryolite. Purity of the alumina must be greater than 99.5% Al_2O_3 on a dry basis.

In general, 4.5 short tons (4 long tons) of bauxite yields 2 short tons of alumina and 1 short ton of aluminum. Through improved technology, there has been some small increase in yield over the years.

Currently there is no competitive free world process or source of aluminum.

Other Possible Future Sources and Technologies of Production

The primary concern of this report is the consideration of the use of domestic sources of aluminum raw materials. Because of the scarcity of domestic bauxite, other domestic materials and processes must be considered. In all cases, reserves of ore and competitive economics are the key factors to utilization of a domestic source of aluminum. Foreign raw materials, other than the previously discussed bauxite and alumina, will not be discussed.

In December 1970, the National Materials Advisory Board (NMAB) issued a report entitled Processes for Extracting Alumina from Nonbauxite Ores. (Ref. 6.) The summary of conclusions and recommendations from this report is quoted in its entirety in Appendix 1.

The study covered by the NMAB report considered the following raw materials: clay, dawsonite, aluminum phosphate rock, anorthosite, copper leach solutions, saprolite, aluminous shales, alunite, and coal ash. On the basis of the domestic quantity available or the economics of processing, the NMAB report eliminated all of the above materials except clay and dawsonite. Anorthosite has been reported to be under reconsideration and will be discussed briefly. A current evaluation of an alunite deposit has been announced as under study in Utah.

Kaolin. Of the above materials, clay (kaolin) appeared in the NMAB report to have the best potential, with a nitric acid (Nuvalon) process for obtaining alumina from clay having the lowest projected cost per ton of alumina.

The reserves of kaolin in Georgia alone appear more than adequate for years to come. Many of these deposits meet large usage mining requirements in terms of size and location. Information from proprietary sources in the kaolin industry has indicated approximately 3 billion tons of kaolin reserve south of the Fall Line between Augusta and slightly west of Macon. The Georgia Department of Mines, Mining, and Geology has stated that there is at least an additional 2 billion tons south of the Fall Line between Macon and the Chattahoochee River. Most, if not all, of the Augusta-Macon reserve estimates are reported to be based on company drilling. An undetermined number of properties are leased under 50 year or longer agreements or are owned in fee simple by kaolin companies. The same is reported true southwest of Macon for the remaining 2 billion or more tons. At a meeting held at Georgia Tech in September 1970, at which key representatives of both the aluminum and kaolin industries were present, the above reserve tonnages were brought out on the open floor. They were confirmed verbally by representatives of the kaolin industry.

Most of the above reserves have been discovered since about 1961. The extreme proprietary nature of the kaolin industry as it has and does exist has precluded more detailed reserve information for public dissemination. This, however, does not invalidate its accuracy.

As noted above, the requirement of reserve tonnage of alumina in clays appears to be exceeded in Georgia alone. The Georgia kaolins contain about 35% alumina, with some having as much as 39% alumina. A conservative estimate has been used of 30% of the kaolin being recovered as alumina. Allowing a 2:1 ratio of alumina to aluminum, 15% of the kaolin can be recovered as aluminum, which means that roughly 1.5 billion tons of alumina or 750 million tons of aluminum can be recovered from reported reserves of kaolin in the state of Georgia.

The most promising process available for this study for recovering alumina from kaolin, on the basis of process costs per ton of alumina, is a new nitric acid method on which the patent was granted on July 22, 1971, to R. W. Hyde and S. V. Margolin and assigned to Arthur D. Little, Inc.

The nitric acid process evaluated by the U. S. Bureau of Mines and used for costs in the NMAB report was a modified Nuvalon (German) process.

As shown later in this report, when current (March 1972) utility costs for an Augusta-Macon site are substituted for the older costs used in the NMAB report, the estimated costs per ton of alumina rises from the \$58 used in the report for the nitric acid (Nuvalon) process to in excess of \$71 per ton. On the other hand, when current utility costs as well as 1972 construction, labor, and mining costs are used for estimating in the Hyde-Margolin process, Hyde (personal communication) estimates a cost of less than $62 per ton of alumina or approximately $48 per ton with the recommended depletion. This may be compared with costs reported in the NMAB study of $47 per ton of alumina by the Bayer-bauxite process which is reported to have risen to $48 per ton in 1972.

The reduction of costs by the Hyde-Margolin process over the Nuvalon process appears to be effected by use of less energy and time. A step-by-step comparison of temperature requirements shows that in each instance, excepting calcining, the Hyde-Margolin process operates at lower temperatures. In addition, heat is systematically carried forward from step-to-step in continuous flow. Time for digestion is reduced from six to three hours. Time for settling out waste silica was 14 hours in the Nuvalon process as compared to continuous flow and flocculation in the Hyde-Margolin process. Other economies are found throughout.

Dawsonite. The consideration of dawsonite [$NaAl(OH)_2CO_3$] involves mining and processing of oil shales in which dawsonite would be a by-product. Under optimum conditions the alumina content of the shale is approximately 4%. It has been considered by industry and federal agencies because of expected large quantities of calcined shale waste if oil shale is mined for the production of oil. In addition to mining costs, consideration must be given to the costs of recovering the 4% alumina content while handling, processing, and disposing of as waste the other 96% of the shale. Further, it is reported that the best sources of dawsonite are deeply buried and would be available only after a large amount of mining has taken place.

Another consideration is that in situ recovery of the oil may be attempted through nuclear processing. If nuclear in situ processing of the shales for oil is used, it would obviously eliminate their use for aluminum. If mining is used, the future is still somewhat unsettled, with a large number of undetermined variables, among which are timing, amounts to be recovered for oil, and costs per ton of alumina. The recovery of alumina is dependent on the mining of the shale for oil.

Dawsonite reserves of aluminum are immense, however, being projected as over 4 billion tons of recoverable aluminum. Because of the enormous reserves, it may well be the reserve of the future, but not the relatively near future material needed now.

Anorthosite. Also reported to be under consideration by industry as a source of alumina is anorthosite. In its favor are the large deposits of anorthosite within the United States. Most of the deposits, however, are not in easily accessible locations. Further, process costs estimated in the NMAB report, even though based on outdated equipment costs (1960) and fuel costs, came to $74.36 as the lowest projected cost per ton of alumina. Electric costs could be in line if production has access to the large hydroelectric sources of the western United States, but the estimated 2.5 cents per therm of natural gas probably should be doubled. This doubling, when applied to the steam and natural gas costs alone, would change the estimated per ton costs of alumina to approximately $88 per ton.

If the estimated costs per ton of alumina for the Hyde-Margolin, Arthur D. Little process for clay is $62 per ton of alumina, the economics of producing alumina from anorthosite in excess of $88 are obviously prohibitive.

Alunite. Alunite $[KAl_3(OH)_6(SO4)_2]$, which contains approximately 37% Al_2O_3, was rejected in the NMAB report as not being in sizable quantity in the United States. Discovery of a large deposit in Utah was announced recently. (Ref. 8.) Jointly held by National Southwire Aluminum Co. and Colorado Central Mines, Inc., the deposit is currently under investigation. Size of deposit and projected cost per ton of aluminum are still in the investigative stages. By-products from an Al_2O_3 from alunite process could be a potassium sulfate fertilizer and alum. Delivered costs of alumina to eastern reduction plants may reduce or eliminate its competition with kaolin in this area but favor it for western plants.

Direct Reduction Methods. Studies are currently being made of direct reduction methods for producing aluminum from an ore without going through present steps. A favored means has been production of $AlCl_3$ by chlorination and subsequent chemical reductions. Work reported to date has not proved feasibility according to the U. S. Bureau of Mines. (Ref. 3.)

Chapter 3

BALANCE OF TRADE CONSIDERATIONS ATTRIBUTABLE TO ALUMINA AND BAUXITE

It is estimated that imported bauxite and alumina for use by the domestic aluminum industry will contribute approximately $294 million to the dollar outflow from the United States in 1972, increasing to a projected annual outflow of approximately $835 million by 1985, if based on conservative estimates and present nationalizations.

This chapter delineates the background and methodology of determining the United States dollar outflow attributable to imported bauxite and alumina. Projected requirements for raw materials are discussed, and their probable effects on the U. S. economy in terms of imports and dollar outflow are considered.

Demand for Aluminum

Identification and the subsequent quantification of the demand for aluminum were the first steps in estimating the related dollar flows due to imported raw materials.

Table 1 lists the consumption of aluminum by U. S. industry.

Table 1

RELATIVE CONSUMPTION OF ALUMINUM BY INDUSTRY GROUP

Industry	Percent of Total
Construction	23
Transportation	20
Electrical and Communications	14
Special Machinery*	14
Consumer Durables	11
Packaging	11
Other	7
	100

* Industrial, agricultural, material handling, irrigation, chemical, metallurgical and dissipative uses.

Source: U. S. Bureau of Mines, Mineral Facts and Problems, 1970.

The U. S. Bureau of Mines has estimated that in the year 2000 domestic demand for aluminum will range between 21.2 and 42.0 million tons. (Ref. 9.) This represents an average growth rate of 5.1% to 7.4% annually.

Projections over a shorter time period are generally more reliable because technological changes which take considerable time to implement can affect performance at a later date. To reduce the probability of error, therefore, the shorter period of 1972-1985 was used in the following analysis.

The National Materials Advisory Board has calculated from the Bureau of Mines data that by 1985 the demand for aluminum in the U. S. will be between 9.0 million and 12.7 million tons annually. (Ref. 6.) The growth of this demand is shown in Table 2.

Table 2

PROJECTED U. S. DEMAND FOR ALUMINUM

Year	Range Million Short Tons Low	Range Million Short Tons High
1972	4.8	5.6
1973	5.0	6.0
1974	5.5	6.5
1975	5.7	6.8
1976	5.9	7.5
1977	6.0	7.75
1978	6.5	8.3
1979	6.8	8.7
1980	7.4	9.0
1981	7.5	10.0
1982	7.75	10.8
1983	8.3	11.5
1984	8.7	12.2
1985	9.0	12.7

Supply of Raw Materials

In 1965 world bauxite reserves, including inferred bauxite, were estimated to be 5.8 billion tons. Potential bauxite resources were estimated to be 9.6 billion tons. The estimated world reserves of aluminum are shown in Table 3.

Table 3

ESTIMATED WORLD RESERVES OF ALUMINUM

	Millions of Tons	
	Bauxite[1/]	Aluminum Equivalent[2/]
North America		
United States		
Arkansas	44	8.8
Southeastern States	1	.2
Total	45	9.0
Caribbean Islands		
Dominican Republic and Haiti	85	17.0
Jamaica	600	120.0
Total	685	137.0
South America		
Brazil	40	8.0
Guyana	80	16.0
French Guiana	70	14.0
Surinam	200	40.0
Total	390	78.0
Europe		
Austria	1	0.2
France	70	14.0
Greece	84	16.8
Hungary	150	30.0
Italy	24	4.8
Rumania	20	4.0
Spain	7	1.4
U.S.S.R. (including Soviet Asia)[3/]	300	60.0
Yugoslavia	200	40.0
Total	856	171.2
Africa		
Ghana	290	58.0
Guinea	1,200	240.0
Mozambique	2	0.4
Malawi	60	12.0
Sierra Leone	30	6.0
Total	1,582	316.4

Table 3 (continued)

	Millions of Tons	
	Bauxite 1/	Aluminum Equivalent 2/
Asia		
China, Mainland	150	30.0
India	64	12.8
Indonesia	20	4.0
Malaysia		
Peninsular Malaysia	10	2.0
Sarawak	5	1.0
Turkey	30	6.0
Total	279	55.8
Oceania		
Australia	2,000	400.0
Palau Islands	5	1.0
Total	2,005	401.0
Total for world	5,842	1,168.4

1/ Metric or long tons, dry basis; however, many estimates used in compilation failed to designate type of tons used and whether tonnages had been converted to dry basis.

2/ Short tons.

3/ Estimate probably includes much low-grade bauxite that would be classed as potential resources in other countries and possibly aluminous rocks other than bauxite.

Source: U. S. Bureau of Mines, Mineral Facts and Problems, 1970.

The United States relies on the Caribbean area (Jamaica, Dominican Republic, and Haiti) and northeastern South America (Surinam and Guyana) for over 85% of its bauxite supply.

Table 4 projects the trends in the aluminum equivalent of imported bauxite and alumina beyond the year 1969 with actual figures from 1965-1969. In addition to these imports of bauxite and alumina, aluminum also will be imported to augment the domestic supply.

Table 4

ACTUAL AND PROJECTED IMPORTS OF BAUXITE AND ALUMINA, 1965-1985
(Aluminum content in thousands of short tons)

Year	Bauxite	Alumina	Total
1965	3,233	120	3,353
1966	3,321	259	3,580
1967	3,342	504	3,846
1968	3,166	697	3,863
1969	3,474	997	4,471
1970	3,667	1,084	4,751
1971	3,776	1,369	5,145
1972	3,879	1,644	5,523
1973	3,988	1,892	5,880
1974	4,094	2,171	6,265
1975	4,252	2,500	6,752
1976	4,335	2,620	6,955
1977	4,464	2,856	7,320
1978	4,597	3,092	7,689
1979	4,733	3,328	8,061
1980	4,874	3,565	8,439
1981	5,018	3,801	8,819
1982	5,168	4,037	9,205
1983	5,321	4,273	9,594
1984	5,480	4,510	9,990
1985	5,642	4,746	10,388

Source: Data for 1965-1975 from National Materials Advisory Board, Processes for Extracting Alumina from Nonbauxite Ores, Publication NMAB-278, National Academy of Sciences-National Academy of Engineering, Washington, D. C., December 1970, p. 9. See Appendix 2 for methodology for projection of data for 1976-1985.

Dollar Flow Attributable to Imported Bauxite and Alumina for Use in Producing Aluminum

Bauxite. The U. S. Bureau of Mines reports the United States imports of bauxite in 1969 as 12,180,000 long tons at a value of $165,802,000 -- an average of $13.61 per long ton. (Ref. 5.)

Alumina. Imports of alumina for 1969 are reported by the U. S. Bureau of Mines as 1,912,000 short tons at a value of $106,333,000 -- an average of $55.61 per short ton. (Ref. 5.)

Estimated Value of Future Imports. Estimated annual bauxite and alumina imports for the years 1972 through 1985 are listed in Table 5.

Table 5

ESTIMATED VALUE OF BAUXITE AND ALUMINA IMPORTS, 1972-1985
(in thousands)

	Bauxite (long tons)	Value	Alumina (short tons)	Value
1972	15,504	$ 211,009	3,288	$ 182,846
1973	15,952	217,107	3,784	210,428
1974	16,376	222,877	4,342	241,459
1975	17,008	231,479	5,000	278,050
1976	17,340	235,997	5,240	291,397
1977	17,856	243,020	5,712	317,645
1978	18,388	250,261	6,184	343,892
1979	18,932	257,665	6,656	370,140
1980	19,496	265,341	7,130	396,499
1981	20,072	273,180	7,602	422,747
1982	20,672	281,346	8,074	448,995
1983	21,284	289,675	8,546	475,243
1984	21,920	298,331	9,020	501,602
1985	22,568	307,150	9,492	527,850
Total	263,368	$3,584,438	90,070	$5,008,793

Note: Aluminum content figures in Table 4 converted at ratio of 1:4 for bauxite and 1:2 for alumina. Value based on 1969 average value per ton.

At 1969 value and assuming the continued dependence on foreign sources of raw materials for aluminum production, it is estimated that a total of approximately $8.6 billion will flow from the United States over the next 14 years to import bauxite and alumina.

The valuations of imported bauxite and alumina are usually F.O.B. export country.1/ Insofar as any shipments to the U. S. are made in foreign vessels, the shipping charges would constitute a further dollar outflow.

1/ Statement by U. S. Customs Agent, Classification and Valuation Section, New Orleans, Louisiana.

Chapter 4

RESEARCH NEEDED FOR A DOMESTIC ALUMINA-FROM-KAOLIN INDUSTRY

Recommended Research

In previous chapters of this report, the following facts and conclusions have been considered:

1. The consumption of aluminum in the United States and the free world is expected to grow at a rate of at least 5% annually.

2. Bauxite is the only ore of aluminum used at present in the free world for commercial production of aluminum.

3. Within eight years it is projected that 95% of the United States' requirements for primary aluminum will be imported, if present trends continue.

4. At 1969 values and assuming the continued dependence on foreign sources of raw materials for aluminum production, it is estimated that a total of approximately $8.6 billion will flow from the United States over the next 14 years to import bauxite and alumina.

5. The National Materials Advisory Board has concluded that an acid process for the treatment of domestic clay (kaolin) appears to be the most promising for the economic production of alumina from materials other than commercial bauxite.

In light of these considerations, it is concluded that there is a critical need for the development of an alumina industry in the United States based on large-quantity domestic ore sources. It is recommended, therefore, that direct full funding be allocated to be used or administered by the U. S. Bureau of Mines, in cooperation with industry, for the purpose of definitive research directed toward obtaining the best economic and technical method(s) for obtaining alumina from domestic sources of kaolin clay.

On the basis of present information, it is recommended that a nitric acid process for clay, using the best available knowledge, be tested in a 5-ton-per-day integrated pilot plant to determine if operational technology and estimated costs of operation are correct and may be scaled to a larger plant. If the 5-ton-per-day pilot plant proves technical feasibility and economic justification, it is recommended that direct full funding be allocated for a

50-ton-per-day pilot plant, with administration through the U. S. Bureau of Mines continued.

Pilot Plant Time and Cost Considerations

The recommended integrated pilot plant is projected to operate at a capacity of five tons per day of alumina product. The use of a smaller plant could decrease the accuracy in scaling up to a 50-ton-per-day plant. A minimum time period is projected as three years from the time of funding, with the possibility that three to four years may be needed. Funding for the total operation is estimated to be between $15 and $20 million. In terms of allocated budgeting by the Congress or executive order, it is recommended that project funding be for a total not to exceed $20 million for four years nor more than $8 million in any one year. This is a research rather than a testing program, and the possibility of a year's slippage due to unpredictable problems has been considered in the projected time period. Three years is the actual minimum estimated time and, if concluded in this time, funds should be allowed to apply on a 50-ton-per-day pilot plant.

The first year should include laboratory evaluation by the U. S. Bureau of Mines to determine process details and design characteristics for placing the pilot plant construction operation out for bid to industrial organizations. Bid letting based on this laboratory work is anticipated before the end of fiscal 1974, with perhaps some subcontracting or material purchases being made in fiscal 1974. The second year should see full-scale operation of the pilot plant. The third year may include some modifications and phase out of the project. It would also include recommended design of a 50-ton-per-day pilot plant and possibly costs estimates and recommendations to the Congress.

The above 5-ton-per-day pilot should give reliable figures and operating detail that will permit a tenfold scale up to a 50-ton-per-day pilot plant. Costs estimates for a 50-ton-per-day pilot plant are meaningless at present because of the number of undetermined variables. On a unit basis, however, the cost should be substantially lower. Some of the unit reduction will come from experience and some from the fact that the product should be salable. Recommendations to the Congress for funding a 50-ton-per-day plant are anticipated in fiscal 1976 or 1977.

The preceding recommendation is for a single 5-ton-per-day pilot plant using a nitric acid process on clay. This recommendation is on the basis that present knowledge, not available for the NMAB report, indicates that the technology and economics are more favorable for a nitric acid process using kaolin as the domestic material than for any other known process or domestic material excepting bauxite. Projections of cost show a nitric acid-kaolin process to be in a competitive range of the Bayer-bauxite process. Should two or more processes and/or materials be indicated as competitive by the U. S. Bureau of Mines comparative evaluations, two essentially simultaneous 5-ton-per-day pilot plants may be called for in order to document through operation the comparative costs of the two closest competing systems or materials. In this event, the Congress could be so approached for a fiscal 1975 increase in funding. In no case is it anticipated, however, that a total of more than $35 million would be needed.

Pilot Plant Process Considerations

The operating costs per ton of alumina from kaolin for nitric acid, sulfurous acid, and hydrochloric acid processes were estimated to be $58, $62, and $63, respectively, by F. A. Peters, R. C. Kirby, and K. B. Higbie in 1967. (Ref. 10.) These were based on a plant producing 1,000 tons of alumina per day. Five other processes for nonbauxite ores were also given. Most costly was a potassium-alum process at $97 per ton of alumina. Alumina from the Bayer-bauxite process was shown as $47 per ton.

In 1970 these processes were reviewed by a committee appointed by the National Materials Advisory Board, who used the same process costs as the 1967 Peters report. (Ref. 6.) They recommended small (1 to 5 tons per day) pilot plants on the nitric acid and hydrochloric acid processes for kaolin, followed by a 50-ton-per-day pilot plant based on the best process of the two smaller pilot plants. Since that time additional proprietary research has indicated that the problem of iron removal in a hydrochloric acid process may cause prohibitive costs. This then leaves a nitric acid process. The nitric acid process used for an estimate of $58 per ton of alumina was essentially the German Nuvalon process.

Energy consumption has been estimated to be approximately three times that of the Bayer-bauxite process in most kaolin-to-alumina methods. The largest energy source used in the Nuvalon nitric acid process was natural gas. Johnson (Ref. 11), Peters (Ref. 10), and the NMAB report (Ref. 6) used a cost of 2.5 cents per therm (100,000 BTU) of natural gas. Present (1972) rates in the Fall Line of Georgia area are approximately 5 cents per therm as a minimum. Cost for electrical energy in the above reports was 5 mills per kwh. The rate for electricity will depend on a combination of amount of energy and a demand factor, but will probably be between 8 and 9 mills per kwh in the Fall Line area of Georgia. The relative amount of electricity, however, is not a major cost item in the per ton costs of alumina from kaolin.

In attempting to estimate the impact of energy cost increases on the costs per ton of alumina from kaolin, it was found that different figures had been used in the energy required for steam. Total costs of natural gas (steam plus other) were given as $15.50 by Johnson (Ref. 11) and $12.86 by Peters (Ref. 10). When doubled, they change the estimated cost per ton of alumina from $60.69 to $76.19 and from $58.05 to $70.91, respectively. Since these figures were derived on the basis of the same costs per therm of natural gas and the same process (Nuvalon), it is assumed that the water consumption would be the same and hence the cost reduction was due to more efficient transfer of energy or a lower requirement for steam pressure and temperature. This is not necessarily correct, however, since an unpublished recent "print-out" using the same cost basis showed $17.77 per ton of alumina for natural gas energy and changed the cost per ton of alumina from $58 to $75.77 per ton. The problem of the above differences in energy costs (and as they are reflected in total costs) is not that they are different, but that they are based on different estimating bases from laboratory scale experiments or computer models, each of which may have a valid assumption base. The solution appeared to be not in more estimates, but in an integrated pilot plant to obtain actual cost data on a much larger scale, as recommended by the National Materials Advisory Board.

Patent number 3,586,411, "Method for Extracting Pure Alpha-Alumina from Clays," was granted to Richard W. Hyde and Stanley V. Margolin on June 22, 1971. It has been assigned to Arthur D. Little, Inc. This process differs from the Nuvalon method in several significant ways, all of which seem to be in the direction of lowering costs. Among these are lower temperature and atmospheric pressure for leaching the clay with nitric acid with three hours residence instead of six hours, flocculation instead of settling tanks (continuous process versus 14-hour settling), removal of iron by ion exchange, fluidbed with continuous flow versus steam chambers for nitrate disassociation and removal (and with less temperature), and what appears to be an overall lower energy requirement at each significant state of processing.

A cost estimate given by R. W. Hyde (personal letter) is less than $62 per ton of alumina using current (March 1972) utility, construction, labor, mining, and overhead in Georgia. Utility costs used in this estimate were 5 cents per therm for natural gas (50 cents per million BTU) and 8.45 mills per kwh of electricity. Labor is as shown in Chapter 6. Mining cost is at $2 per ton of clay. It is interesting to note that Hyde and Margolin had an estimated cost of $39 per ton of alumina as based on 1967-1968 cost figures. As current costs were used, this was increased as follows: energy, $7 per ton; construction, $7 per ton; mining, $5.52 per ton; labor, $1.75 per ton; and overhead, $1.50 per ton, for a total increase from $39 to $61.77 per ton. A depletion of 22% to the alumina stage could reduce this to slightly more than $48 per ton of alumina.

In recommending an integrated pilot plant using a nitric acid process, the authors of this report are recommending the most efficient, lowest cost process available, to be determined by the U. S. Bureau of Mines. The Arthur D. Little (Hyde-Margolin) process appears to be the best at present, but there may be refinements or changes that may be incorporated from other workers in the field. It is hoped that the various United States aluminum and/or chemical companies who have worked on this problem will, with enlightened self-interest, cooperate with the U. S. Bureau of Mines to achieve a pilot plant operating with optimum state-of-the-art technology.

Pilot Plant Sponsorship Considerations

The recommendation for a pilot plant to produce alumina from kaolin is based on designing an integrated operation which will include all known improvements in order that they may be evaluated for a larger scale pilot and later commercial plants. Obviously this will require disclosure, permission to use, and protection of proprietary knowledge and interests. It may well take federal government action through supervision and funding to include the new technologies of diverse proprietary interests into a single integrated pilot plant. Certainly the U. S. Bureau of Mines seems the ideal agency to let contracts and supervise this operation.

Funding for the U. S. Bureau of Mines could be a problem if the Office of Management and Budget does not permit funding for this project to be over and above the regular U. S. Bureau of Mines budget. A reason for this is that the proposed annual budget for a pilot plant is equal to or exceeds the annual metallurgical research budget of the Bureau, and hence the pilot plant could, presumably, eliminate any other metallurgical research, including personnel.

There are several answers to the question of why private industry should not fully or partially fund a pilot plant. Included in these answers are the following:

1. The immediate past and present state of the economy has severely curtailed or eliminated research and venture funds of the aluminum companies. Included in this economic squeeze have been cutbacks in production, labor force, etc.

2. Research brought to an operating stage could be copied and patent litigation is expensive. Further, expenditure of company funds to help the competition is not good business.

3. Proprietary information held by several companies could be more easily used in a single pilot plant if funded by the federal government.

Reasons for U. S. government funding are the enormous values that should accrue to the nation in terms of (1) reversals of trade deficit, (2) reducing vulnerability of United States aluminum companies in foreign countries, (3) improvement of the country's strategic logistical exposure, (4) generation of tax dollars in the United States that are now going to foreign governments, and (5) improved employment within the United States both in total numbers and in contributing to the reversal of the flow of persons from rural to urban areas. These and other impacts of a domestic alumina-from-kaolin industry are considered in the succeeding chapters of this report.

Chapter 5

INTERNATIONAL IMPACT OF A DOMESTIC ALUMINA-FROM-KAOLIN INDUSTRY

A domestic alumina-from-kaolin industry would have a number of favorable impacts on the United States' international position. These may be summarized as follows:

First, it would assist in reversing the United States' increasing dependency on foreign aluminum raw materials that is projected to be 95% by 1980 if bauxite continues to be the sole source of aluminum. This reversal also will be in the direction of improving this country's balance of trade relationships and dollar deficit position, while creating new employment and taxes within the United States.

Second, it should improve business and political relationships with countries supplying the United States with bauxite and other aluminum raw materials.

Third, it would improve the U. S. military logistical exposure for aluminum.

Effect of Time on International Impact

In all of the above, time is a critical factor in determing the total impact. If allocated funds for a federally sponsored pilot plant project were to be made available by Congress effective July 1, 1973, it is anticipated that it would be 1980 to 1982 before the first commercial plant of 1,000 tons per day could be on stream. An executive order from the President of the United States could conceivably get pilot plant action sooner and would be the first place to accelerate the program.

A minimum of three years would be required from the time that funds become available for an initial 5-ton-per-day pilot plant to where sufficient documented data would be accumulated to permit design improvements to be incorporated in the development of a 50-ton-per-day pilot plant. An additional three to five years would be required (construction, operation, etc.) to have data to construct a 1,000-ton-per-day first commercial plant. Total elapsed time from first funding of a pilot plant to first commercial production is thus projected as six to eight years.

The number of companies that will enter into construction and operation of first generation commercial plants is unknown. These first generation commercial plants should also be considered as being experimental, hence a time lapse of three to five years operation should be considered as realistic before much larger scale second generation plants are feasible. When design and construction time is added, five years appears reasonable. Hence, under non-emergency conditions a time lapse of a minimum of 11 years is projected before a large-scale second generation alumina-from-kaolin plant would be constructed -- and probably 12 years before it goes on stream from time of availability of funds for a first pilot plant program. If funding were available on July 1, 1973, the beginning of more substantial alumina production from Georgia kaolin could not be expected before 1985. This is five years after the projected time that only 5% of the U. S. annual requirement of aluminum raw materials will come from domestic bauxite. Acceleration possibilities are (1) a quicker start by presidential executive order and/or (2) acceleration by commercial plants after the second pilot plant.

U. S. Balance of Trade

A substantially improved position in the United States' balance of trade resulting from a domestic alumina-from-kaolin industry is not expected to be forthcoming until second or later generation plants come on stream. The projected impact between 1980 and 1985 in dollar flow reversal should be on the order of $78 million total for four years for each 1,000-ton-per-day alumina plant, provided a pilot program is started in early 1973. While this is not impressively large in view of the $2,991 million estimated value of aluminum source imports during the four-year period 1981-1984, it must be evaluated in light of the fact that this is production from experimental plants versus much larger scale plants that should follow.

The recommendations for low-cost loans and investment credits (see "Conclusions and Recommendations" section of this report) are for the purpose of accelerating industry action to obtain substantial domestic production of alumina from kaolin. Using projected annual data in Table 5, value of 1985 imports of bauxite and alumina is projected as $835 million. Annual domestic trade reversal to 25% to 50% of this, say during the period 1985-1995, obviously would have a substantial favorable economic impact for the United States.

Relationships with Source Countries

The improvements of the negotiating position of the domestic aluminum companies is considered to rank high -- if not first -- as an immediate and long-range impact of a domestic alumina industry.

In light of growing nationalization in many countries where United States companies are mining bauxite, the continued dependence on bauxite as the sole source of raw material for aluminum leaves U. S. industry vulnerable not only in negotiating new agreements in foreign countries but in preserving the integrity of old agreements. Expropriation may not take place, but the temptation of expropriation and of creeping encroachment of management and profits is magnified by the lack of domestic sources if bauxite alone is considered.

In regard to the problem of foreign aluminum sources for the United States, the strong possibility of using domestic aluminum sources should have an immediate salutary impact on relations with existing source countries. A pilot plant and eventual commercial production could serve as a deterrent of consequence in abuse of overseas aluminum source negotiations. It is anticipated that foreign sources will be used for years to come, even with a domestic source industry.

If the expenditure of $20 million by the federal government for an alumina-from-kaolin pilot plant prevented expropriation in one instance, it would have paid for itself many times over in terms of capital investment of United States funds, loss of profit source, loss of commodity source, and loss of taxes -- not to mention loss of prestige.

U. S. Strategic Logistical Exposure

In addition to the above economic considerations, another important element of concern is the fact that the imported aluminum raw materials move to this country by water. In view of a projected 95% import dependency by 1980 if bauxite alone is used as a source of aluminum, the strategic logistical exposure of the United States could become acute.

Stockpiles of aluminum, alumina, and bauxite are maintained. The size of these stored resources are governed by the logistical expertise and prediction capability of the federal government, the economics of storage, and the nation's economy.

It is not possible to predict the likelihood or possible duration of a military conflict in the future. Some feel that if an armed conflict were to occur between the United States and another major nation it would be short lived because of nuclear warfare and that present stockpiles of materials would be more than adequate. On the other hand, technologies of wars are frequently unpredictable. To this end, there are schools of thought that do not believe the nuclear bomb would be used -- certainly not initially. A long war, dock strikes either here or abroad, or other unforeseen circumstances could deplete or seriously reduce the United States' stockpiles of aluminum and strategic raw materials.

Chapter 6

IMPACT OF A DOMESTIC ALUMINA-FROM-KAOLIN INDUSTRY ON EMPLOYMENT AND REVENUE

The purpose of this chapter is to identify the estimated manpower requirements, special skills needed, potential wages, and economic impact of the new jobs that might result from the establishment of each 1,000-ton-per-day commercial alumina plant for producing alumina from kaolin in Georgia. A nitric acid process will be used as a basis for analysis, since the estimated cost per ton is the most promising of many processes considered by the project team. The estimated cost of $61.77 per ton of alumina for the Hyde-Margolin process includes comparable labor costs as shown herein.

Background

To date, the nitric acid process for producing alumina from clay has only been done in the laboratory. No company or government agency is known to have established or operated a nitric acid integrated processing facility. However, it has been recommended by the National Materials Advisory Board that integrated pilot plants be established for use of clay (kaolin) for the production of aluminum. The report from this Board states, "The most likely areas where clay containing approximately 35% alumina and in deposits of 50 million tons or more can be considered available for aluminum are: (1) the Georgia-South Carolina kaolin belt in which deposits are of Cretaceous age; (2) a belt of Eocene Age deposits which includes the Andersonville district, Georgia, and extends northeast and southwest of this area; and (3) the Arkansas bauxite region." (Ref. 6.)

During the past 30 years much laboratory research and evaluation has been done to develop methods, techniques, and processes for extracting alumina from kaolin suitable for aluminum production.

Personnel at the College Park Metallurgy Research Center, Bureau of Mines, College Park, Maryland, have performed laboratory research and evaluation and have compiled a large amount of data on the Nuvalon nitric acid process. They have also developed a computer program to calculate capital and operating costs from material and energy requirements and equipment costs for use in preparing cost estimates for metallurgical process, manufacturing, and evaluation. Since ongoing laboratory research evaluation has continually changed the nitric acid process, the Center's computer program permitted its users recalculation of processing costs when changes of data or equipment made this desirable.

Estimated operating costs were based on a 350-day year, 24-hour-per-day operation, allowing 15 days downtime for inspection, maintenance, and unscheduled interruptions.

The direct labor costs for the nitric acid process were estimated on the basis of manning the plant with 4.2 employees for each job that operates 24 hours per day, 7 days per week, and 1.4 employees for each job that operates 8 hours a day, 7 days a week.

Based upon data provided by the evaluation group, estimates were made of the manpower requirements, special skills needed, potential wages, and economic impact of the new jobs that might result from the establishment of a 1,000-ton-per-day nitric acid processing plant for producing alumina from kaolin in Georgia.

Manpower Requirements

Estimated manpower requirements for operating a 1,000-ton-per-day nitric acid facility are summarized as follows:

Number of Employees	Type of Job	Skill	Rate of Pay	Annual Payroll Dollars
118	Plant Production Workers	Semiskilled to highly skilled	$3.70 per hr.	$ 908,100
14	Plant Production Supervisors (the above includes clerical help)	Skilled	4.70 per hr.	136,200
55	Plant Maintenance Workers	Highly skilled	6.30 per hr.	724,800
9	Plant Maintenance Supervisors (the above includes clerical help)	Highly skilled	7.75 per hr.	145,000
1	Plant Manager			30,000
1	Assistant Plant Manager			20,000
1	Secretary			7,000
1	Receptionist			5,500

Number of Employees	Type of Job	Skill	Rate of Pay	Annual Payroll Dollars
4	Engineers			$ 64,000
1	Draftsman			8,000
1	Chemist			18,000
2	Laboratory Technicians			16,000
2	Safety Engineers			28,000
12	Plant Guards and Firemen			90,000
1	Chief Accountant			19,000
1	Senior Accountant			14,000
2	Clerks			12,000
1	Secretary			7,000
1	Purchasing Manager			15,000
1	Secretary			6,500
1	Marketing Manager			15,000
1	Secretary			6,500
2	Loader Operators	Skilled	$3.70 per hr.	15,390
12	Truck Drivers	Skilled	3.70 per hr.	92,350
3	Equipment Preventive Maintenance Workers	Semiskilled	3.00 per hr.	18,220
2	Motor Grader Operators	Skilled	3.70 per hr.	15,390
2	Mining Supervisors	Skilled	4.70 per hr.	19,950
252	Total			$2,457,300
	Payroll Overhead (Fringe Benefits) Includes vacations, pensions, workmen's compensation, insurance, holidays and other fringe benefits.			669,900
	Total			$3,127,200

In addition to the 252 or more direct new jobs created by each 1,000-ton-per-day commercial project, it is expected that 1,000 additional indirect jobs (1:4 ratio) will be created in order to supply the commercial facility and its employees with essential services. This includes heavy equipment maintenance and suppliers of processing chemicals, power, water, gas, communications, and education.

Jobs related to construction of plants are another source of employment that will result from an alumina industry.

Special Skills

Manpower required to operate and maintain an alumina plant will need to be semiskilled and skilled labor with relatively few unskilled workers. Highly skilled technicians will function in the areas of chemical analysis, servo-mechanisms (both mechanical and electrical), and exotic materials fabrication. However, a majority of the employees will be classified as semiskilled and skilled.

Employment Impact

It is difficult to identify the total employment impact the proposed new commercial plant will have on the area, Georgia, the Southeast, and the United States as a whole. However, it is clear that the proposed new facility will establish a new basic industry in Georgia. It will provide new jobs during the construction period. It should provide a minimum of 252 direct new jobs and 1,000 indirect jobs. It should result in minimum annual payroll increase of $2,457,300 plus $669,900 in fringe benefits.

It is also apparent that this new basic industry will have the immediate and long-range effect of providing training opportunities and expanding employment opportunities for the low skilled, unemployed of the area, and enhancing their standards of living.

State and County Revenues

According to the Georgia Department of Revenue, total tax revenue amounted to $100 per $1,000 of personal income in Georgia for 1971. Personal income is defined as income reported by all employees and individuals from all sources. Total tax revenue is defined as all payments derived from the application of local and state tax regulations. State and local taxes collected per $1,000 of personal income for 1971 is presented in Table 6.

Based on this information, it is estimated that the annual tax revenue derived from an alumina plant operating in Georgia would amount to over $245,000 ($2,457,300 payroll x $100 ÷ $1,000 = $245,730).

Table 6

TOTAL TAX REVENUES COLLECTED PER $1,000 OF PERSONAL INCOME BY CATEGORY

Category	Tax Collected
Property	$ 31.00
Sales and Use	20.00
Income	12.50
Corporate	6.25
Other[1/]	30.25
Total	$100.00

1/ Other taxes include cigarette, liquor, motor, fuel, highway use, estate, etc.

This estimate is considered to be conservative because the $100 per $1,000 of personal income is based on total personal income and taxes received in Georgia for 1971. It should be noted that capital investment required to establish an alumina facility will exceed $50 million and consequently will generate far more taxes than the average taxes paid by Georgia industry. Projections have been on a conservative $50 million, but industry sources have indicated that construction costs could be more than double this figure.

A closer estimate of state and county tax revenues that could be derived from the location of a $50 million plus alumina plant in Georgia is best obtained by applying the current tax regulations to the estimated value of land, buildings, equipment, and inventories. Taxes derived from corporate income tax and individual income, property, and sales taxes can also be estimated by applying the pertinent tax regulations to average income estimates and aggregate payroll data. The following method for estimating annual taxes and revenues assumes:

1. An average of 25 mills throughout the Georgia kaolin belt;
2. A 40% assessment ratio as prescribed by state law; and
3. An item value on an estimated cost basis.

Table 7 presents the estimated annual taxes which could be derived from the location of an alumina plant in the Georgia kaolin belt utilizing the above method.

Table 7

ESTIMATED ANNUAL STATE AND COUNTY TAXES FROM ALUMINA PLANT IN GEORGIA

Item	Value	Assessed Value	Taxes
Land and Buildings	9,300,000	3,720,000	$ 93,000
Equipment	40,746,000	16,280,000	407,460
Inventory (one month supply of raw and process materials)	1,944,000	777,000	19,440
Employee			
State Sales Tax (Personal Expenditure) $150 annually x 252 employees1/			33,768
Income Tax $100 annually x 252 employees2/			25,200
Property Tax			
$2.5 million payroll x $31 ÷ $1,0003/			77,500
Corporate Income Tax			N/A
Total			$656,368

1/ From 1971 Optional State Sales Tax Table of the Federal Income Tax Form published by the Department of Treasury, Internal Revenue Service, and based on a family of four with an annual income of $9,751.

2/ Based on a family with two adults, two dependent children, and 10% standard deductions, with an average annual income of $9,751.

3/ Georgia 1971 Statistical Report, State Department of Revenue, Chart 8, p. 14, December 1971.

N/A - Not available.

Because tax regulations allow a minimum 5% annual depreciation of fixed assets, the tax liability of the alumina company will decrease $25,000 annually. However, as new equipment is purchased to replace worn out and depreciated equipment, the annual tax liability will be adjusted to reflect the new values.

Federal Revenue

The Internal Revenue Service has estimated the individual income tax paid by Georgia workers to be $1.5 billion. The Office of Business Economics has estimated the personal income of all Georgia residents to be $14.3 billion. These two statistics indicate that approximately 11% of personal income in the state of Georgia is paid as federal income tax.

The proposed alumina facility would have an annual payroll of approximately $2.5 million dollars, of which 11% would be paid as federal personal income taxes. This would amount to $275,000 annually.

In summary, it is difficult to quantify all of the local, state, and federal revenues which would be derived from the proposed alumina facility. However, it is evident that Georgia could expect to receive over $600,000 in new revenues and the federal government, $275,000. There are other federal taxes not estimated here which would increase the above figures. Examples of such taxes are excise, lubricating oil, gasoline, etc.

Chapter 7

IMPACT OF A DOMESTIC ALUMINA-FROM-KAOLIN INDUSTRY ON THE CURRENT KAOLIN INDUSTRY

The estimated impact on the current kaolin industry of an alumina (Al_2O_3) industry using kaolin as an ore must be based upon the size of the new industry. The principal guides to size used in this estimate are (1) a minimum size commercial kaolin-to-alumina plant of 1,000 short tons of alumina per day and (2) the present and predicted use of aluminum in the United States to obtain an estimated maximum United States alumina requirement. For purposes of estimating, a 30% recovery of kaolin as alumina (averaging 35% Al_2O_3) and a 2:1 alumina to aluminum recovery has been used. Actual aluminum from alumina is 52.9% instead of 50%. Other estimating bases are also considered conservative.

Projected Demand for Kaolin

A 1,000-ton-per-day alumina plant would produce 350,000 short tons of alumina and consume 1,167,000 short tons of kaolin in a year, or roughly one-third of the 1970 Georgia kaolin production.

The National Materials Advisory Board report projects domestic demand in 1985 to be between 9 and 12 million tons of primary aluminum or 18 to 24 million tons of alumina. (Ref. 6.) If 25% of the projected demand were to be met by Georgia kaolin, the annual kaolin requirement would be approximately four times 1970 annual Georgia kaolin production for the lower figure or approximately 5.3 times if the larger figure is correct. The 1970 production of kaolin was 3,749,000 short tons. (Ref. 12.)

Unless accelerated, however, the program proposed in this report does not anticipate second generation commercial plants to go on stream before 1985. A single first commercial plant of 1,000 tons of alumina per day at 350 days per year is only 350 thousand short tons of alumina instead of 4.5 million to 6 million tons that would be projected at 25% of demand. Kaolin requirements for alumina could thus be projected to approximately one-third of 1970 production for each 1,000-ton-per-day alumina plant. In the period 1970-1985, kaolin production for present uses is predicted to rise two to three times 1970 production, or between 7 and 12 million tons. (Ref. 3.)

Impact Possibilities

Obviously, usage of kaolin for alumina until 1985 -- or until second generation plants come on stream -- will have relatively little impact. Second generation plants, if after 1985, could double to quadruple demand if based on 25% to 50% of domestic supplies of aluminum raw materials being met from this source. Based on the above, there emerges several tangible possibilities regarding the impact on the kaolin industry by an alumina-from-kaolin industry.

1. Based on predictions of increased demand for kaolin, whether before, by, or after 1985, there should be much greater competition for reserves. If, as the kaolin industry states, large blocks of reserves are under 50 or more year leases or owned in fee simple by kaolin companies, that competition could take place more at the corporate level than the non-industry landowner's level. This could escalate prices but obviously not to the extent of pricing out of the market. Acquisition of reserves could be by joint ventures between kaolin companies and aluminum companies, purchase of large blocks of leases by aluminum companies, or leases or subleases.

2. There should be an impact on the labor market. A skilled manpower shortage could develop temporarily, coupled with an increase in cost of labor; but there should be, in the long run, a more stable labor force.

3. The demands of the aluminum industry would put a preminum on large deposits of kaolin that could be readily mined in close proximity to the processing plant. Selective mining and selective transportation of grades of kaolin would probably not be economically permissible. This, in turn, would require protection of the high value clays for present uses such as for paper. A question arises concerning reserves for each. The impact here would be to stimulate better knowledge of the reserves through research. This also would be required for better planning.

4. There would be an impact on the tax digest that should help the kaolin companies.

5. Required new power, transportation, and other supply sources could benefit the present kaolin industry.

6. The current nitric acid processes are expected to utilize kaolins that are currently off-grade and hence would favor use of clays that are rejected for present and possible future market use. Therefore, it should

permit disposal of large tonnage reserves of clay of questionable use by the kaolin industry. The impact on the kaolin companies would be in their favor and put them in a much better capital position for research and expansion.

7. Present laws for environmental rehabilitation of mined areas and elimination of air and water pollution will be realistically examined.

8. The expected use of large amounts of process water may result in more water control.

9. By-product SiO_2 from the leaching operation could offer competition as a pigment or filler to "air-float" kaolin.

Chapter 8

SATELLITE INDUSTRIES AND THEIR IMPACT

The types and impact of satellite industries and services that would be required for an alumina-from-kaolin industry must be based on the primary raw materials, production steps, and products. The primary raw materials are kaolin, acid, and water.

Mining Supplies

Kaolin mining itself should not create new satellite industries for supply, as the requirements are mostly those of excavation and mine-to-plant transportation. Services for such mining in terms of repairs are currently conducted by the mining company or the equipment supplier. In the event the alumina-from-kaolin industry should grow to where it would supply a major portion of alumina for domestic use, it is likely that service companies would be created for the industry. In essence, it is a matter of size.

Acid Supplies

If a 1,000-ton-per-day alumina plant were built using nitric acid, a large amount of the acid would be recovered. New supply acid could be on the order of 65 tons per day, or two or three tank cars. It is not likely that a new separate acid plant would be built. More likely would be the use of a supplement to the existing plant using anhydrous ammonia to supply the input to make the required nitric acid.

On the same basis as above, a hydrochloric acid process would probably also ship in its acid requirements. To put it more succinctly, 80 rail cars of alumina product a week will not support a minimum size acid plant.

Transportation

Should three to five plants with an average capacity of 500,000 tons per year of alumina be established, the cumulative output of 1.5 million to 2.5 million tons per year would have considerable effect. At the minimal output of 1,000 tons per day, 80 hopper cars per week would be required to transport the weekly production. A maximum of 556 cars per week would be required to transport 2.5 million tons per year. In making these estimates, a hopper car with a 90-ton capacity was used. The actual number of cars required would be greater than the weekly requirement and would depend on the cycle time of load, transport, dump, and return. The transport factor in terms of distance/time would govern the number of cars in addition to possible back-haul freight.

At this time rail commodity rates for alumina do not exist in the kaolin belt. As a matter of course these rates must be established. The railroads have expressed desire to work with any party desiring to obtain more definitive information.

The four rivers of the area provide a possible transportation mode, but at this time these rivers do not have the necessary channel depths. Should these rivers be developed, the transportation of alumina by barge would be a very real possibility. A majority of the aluminum producers are located on large rivers or have access to port facilities for loading and unloading barges.

The direct effect on the highways is considered negligible. However, the indirect effects due to the economic impact could be considerable. Production plants are staffed with people, and highways transport people and all of the goods and services they require.

Water

A major need for an alumina plant is water. No satellite or service industry is forseen for this, but the hydrology of the area and the environmental and ecological impact must be worked out.

Energy Sources

In addition to raw materials, approximately 103,000 kwh of electrical power will be required per day, as calculated from U. S. Bureau of Mines data on the 1,000-ton-per-day nitric acid Nuvalon process. (Ref. 12.) This new load of electrical service may require new sources. New sources obviously will be required when production moves from experimental to major plants.

Energy for processing will require a large supply of natural gas, coal, or crude oil. For 1,000 tons or more per day of alumina, oil would probably come by rail. In the event of major growth, oil would probably be piped. Coal would be expected to come by rail. The presence of hydrocarbons and acids possibly could lead to satellite chemical production but is viewed as remote under projected conditions. The location of hydrocarbon and acid plants on the Altamaha or Savannah Rivers would enhance this possibility because of the availability of large amounts of water for cooling and processing. The possibility of water transportation is also a consideration.

Alumina-using Industries

The more likely satellite industries will be those using alumina per se. These are listed under the general headings of abrasives, chemical and allied products, and non-clay refractories. Domestic production of these products is predicted to increase three to sixfold by the year 2000. They could be a natural outlet for an alumina industry with or without a major use for aluminum. Satellite industries using alumina would bolster the economy and labor index because of their requirements for skilled and trained labor. Other satellites could be those using the SiO_2 resulting from leaching of kaolin.

Aluminum Reduction Plants

Assuming the continued use of the Hall-Heroult processing method, the location of new aluminum reduction plants will need to be where relatively low-cost electricity is available -- and not necessarily near sources of alumina. The possibility of low-cost electricity from nuclear power plants of more advanced design could make it advantageous to locate some future reduction plants in the area where alumina would be produced, which in turn could lead to an integrated operation including products made of aluminum. In projections to the year 2000, this should be considered a possibility for Georgia, particularly in light of the following projections for nuclear fusion plants made by the Atomic Energy Commission (Ref. 13):

Demonstration of scientific feasibility by 1976 to 1979;
Operation of at least two prototypes by 1980 to 1984;
Operation of at least one demonstration plant by 1990;
Sales of fusion reactors on a commercial basis by 2000.

Such growth as projected could also mean that sources other than kaolin, such as alunite in Utah, also could come into production as domestic competition to kaolin in supplying the United States aluminum industry.

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Chapter 9

ENVIRONMENTAL IMPACT OF A DOMESTIC ALUMINA-FROM-KAOLIN INDUSTRY

The first purpose of this chapter is to identify as many factors as possible that could change the environment if an alumina-from-kaolin industry were to become a reality in Georgia. If factors may be projected as harmful to the ecology or total environment, corrective measures will be recommended for pilot plant testing. Other factors about which insufficient knowledge is available, both as to the factor or its effect, are recommended as part of the research to be included in the pilot plant operation, both for more definitive identification and for remedial testing where indicated.

Mining

Mining would be open-pit or surface mining, sometimes called strip-mining. In the past, kaolin mining has been an eyesore and a detriment in that little if any effort was made to reclaim mined land. This has changed drastically in recent years. Reasons for reclaiming land include the following considerations:

1. The growing public concern over misuse of natural resources enhanced the possibility of restrictive state or federal mining laws on one hand, and better public relations could be achieved on the other.

2. The realization that on a short-term basis it was more costly to reclaim land, but on a long-term basis there was the possibility of it being profitable. Long-term profit could be predicted because (a) increase of land values (provided land was usable) could be predicted on population projections; (b) reforestation and timber farming could be profitable; and (c) recreation areas (fishing ponds, hunting preserves, etc.) could be developed.

The State of Georgia now has surface mine laws that require prior approval for any surface mining.

It is believed that mining of kaolin for its alumina content should not be an environmental or ecological problem because the legal and technical means to enhance the resulting surface and improve the environment are well under way.

In addition to consideration of the land surface before and after mining, the hydrology of mined areas must also be a consideration in the location of each mine site. This will vary from site to site, but of principal interest will be whether or not there will be a negative effect on any down-dip aquifers. A hydrologic study should be mandatory in order that this aspect of the environment may be considered before permission to mine is granted. This may be much more important when some of the thicker and deeper "grey clay" deposits are mined as contrasted to thinner and shallower beds of kaolin of past and present mining.

Another hydrologic consideration in large-scale mining would be the effect on the local water table. Again this should be on a check list of considerations prior to mining as conditions will vary from site to site. Additional hydrologic considerations are given in later sections of this chapter.

In actual mining, emissions from power equipment should be kept minimal. Federal and state regulations will probably establish acceptable standards by the time mining becomes substantial. Mine-to-plant transportation will probably be a covered or enclosed conveyor belt system operated by electric motors. Enclosure would prevent disintegration of clay nodules during periods of heavy rainfall, etc. A closed conveyor system should not be a negative environmental factor.

<u>Processing</u>

Environmental considerations in the processing operations will follow the flow sheet shown in the Hyde and Margolin-Arthur D. Little patent. The chief detrimental possibilities will, in varying degree, be the same for any nitric acid process.

<u>Calcining</u>. The clay will be fed into a rotary kiln where it will be calcined at 700° to 800° centigrade (1292° to 1562°F) to remove all water, including water of composition. Pollution possibilities are dust, fuel oxides (CO_2, etc.), thermal pollution, and water as steam. State-of-the-art methods exist to deal with each of the above pollution possibilities, including recovery and reuse of the water after condensation.

<u>Leaching</u>. Leaching will be approximately at 125°C (257°F) with a 95% to 100% stoichiometric amount with a concentration of 35% to 55% by weight of nitric acid. Pollutants here could be escape of HNO_3 or fumes of same. Proper design and maintenance should eliminate this. Some heat carry-over of the solids from calcining and of the acid from the regeneration in the fluid-bed and heating step is anticipated.

Flocculating and Separating Solids. The chief environmental consideration will be the disposal of solids remaining from the leaching. The solids will be composed primarily of flocculated silica and sand or grit that remains after nitric acid has removed the alumina from the calcined clay. Clay particles are on the order of a micrometer (micron) in size, and their leached remains should be on the same order of size. One consideration has been that this material could be included in the "fill" of land reclamation, but it will require some experimentation to find the optimum way of doing this. The first pilot plant should give sufficient opportunity to make this determination. Use of the silica as a by-product is also a probability, and it is suggested that research directed toward by-product uses of the silica be explored. As an example, the silica should be investigated concerning its use as a pigment, filler, molecular sieve material, abrasive, source of silicon, source of water glass, and/or other uses.

Ion-Exchange Removal of Iron and Other Metals. In this process the principal exchange or stripping liquids are purified and recycled. Trace HNO_3 and HCl in the ion-exchange media are removed by separate water washings. A separate process has been developed to recover the HCl for recirculation and to recover the iron as a high density Fe_2O_3 product. In each of the steps through this one, there has been a stepwise decrease in process temperature, so that thermal pollution is minimized by more gradual dissolution. Further this stepwise decrease has permitted preservation of energy in the process and is in the direction of lowering costs.

Heating in Fluidized Bed. This step requires the reintroduction of substantial energy. Even if natural gas were to be used for initial calcining of clay, coal could be used effectively at this step. Heat of the product in this step is essentially transferred to the next step and further increased. Part of the heat is taken up in an endothermic process reaction of separating the nitrogen oxides from the aqueous aluminum nitrate feed, and part in converting water present to steam and nitric acid. Some thermal pollution could be present but is expected to be minimal as this hot aqueous acid would be circulated hot back to leach the clay.

Care in design, operation, and maintenance should eliminate nitrate pollution as acid or fumes. Recovery of the nitrate as hot HNO_3 for recirculation to clay leaching is part of the lowered economics of the process as both acid and heat are conserved.

Stack exhaust, gaseous or solid, must be dealt with. Solid wastes such as coal ash must be recovered. Fly ash disposal as a salable product or mine fill should be considered. Gaseous products of fuel consumption such as SO_2 and CO_2 should have adequate technology for control by the time a 1,000-ton-per-day plant is established. Best present technology should be applied to pilots for exhaust and fume control.

Heating to $400^{\circ}C$. The problems here have been covered in the previous step.

Calcining to Alpha-Alumina. Less input energy is required because the reaction is exothermic. Exhausts and fumes have been previously covered. Heat dissipation from the product that has been heated to $1000^{\circ}C$ must be dealt with. Energy transfer from the product to one or more of the preceding steps should be sought. Some thermal pollution appears likely. Control within reasonable limits is necessary. Dust elimination or control is mandatory. Transfer of the cooled dry product to storage or shipment in covered hopper rail cars should also have adequate dust control and recovery.

Other Considerations

Water Supply and Wastes. This process uses substantial amounts of water, but the water, as well as other fluids, is recovered and recirculated in most instances. New water needed is then greatly reduced. Even cooling water or liquids seem to be minimized due to the stepwise reduction of the temperature of process fluids and the resulting conservation of energy. Radiation of heat obviously will accomplish some of this reduction of temperature. Again, this is one of the needs of an integrated pilot plant to check design and operating characteristics. Waste water will probably be sent to ponds for treatment, recirculation, or return to natural form.

It is recommended that hydrologists of the U. S. Geological Survey work with personnel of the U. S. Bureau of Mines and state officials in determining the hydrologic impact of an alumina-from-kaolin industry. This would include considerations discussed under mining.

Population. Projected population increases will also require new sewage disposal systems, additional water sources, and other community services which good planning can prevent from becoming environmental problems. Planning and implementation for increase in community size should go hand-in-hand with pilot plant operations.

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APPENDICES

Appendix 1

The following is quoted, with permission, from Processes for Extracting Alumina from Nonbauxite Ores, a report of the Panel on Potentials of Aluminum Extractive Processes of the Committee on the Technical Aspects of Critical and Strategic Materials, National Materials Advisory Board, Division of Engineering - National Research Council, Publication NMAB-278, National Academy of Sciences - National Academy of Engineering, Washington, D. C., December 1970, pp. 1-3.

I. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

A. An acid process for the treatment of clay appears the most promising for the economic production of alumina from materials other than commercial bauxite. The available experimental and pilot plant data for producing alumina from clay appear sufficient to conclude that most of the alkaline processes normally cannot compete economically with acid processes.

Except for meeting the acceptable industry maximum of 0.03 percent Fe_2O_3, the technical feasibility of producing reduction-grade alumina by the hydrochloric extraction from clay has been demonstrated on a small scale. Probably, there would be significant economies in a production plant of large tonnage. This and other economic factors cannot be evaluated except by relatively large and extensive pilot-plant testing.

This Panel recommends that, to obtain comparative figures on the viable acid processes, the Bureau of Mines, with the financial help and cooperation of the domestic aluminum producers, (1) choose a specific HCl process for producing alumina from clay and build and operate a pilot plant of from 1 to 5 tons per day, and (2) select a nitric acid process for producing alumina from clay and build and operate a pilot plant from 1 to 5 tons per day. Hopefully, all of the producers would find it to their advantage to participate.

If the results from either of these pilot plants are successful, a larger pilot plant of 50 to 100 tons per day should be built to obtain the data necessary for scaling up to commercial plant size.

B. Another source of alumina worthy of consideration and more research is the dawsonitic [dawsonite-$NaAl(OH)_2CO_3$] deposits associated with oil shales in the Colorado-Wyoming-Utah area. The large quantity of this potential domestic source of alumina and oil is sufficient incentive to continue the current investigations by the Bureau of Mines and others for more general information and better extractive methods. However, at the present state of technology, a great part of the commercial value of the dawsonitic shales might be lost if nuclear in situ processing were conducted on them.

The Panel recommends that the Bureau of Mines expand its present research program on dawsonite. The program should include detailed mineral surveys of the extent and value of the deposits, the technical variables affecting various recovery processes, and the economics of alumina production in relation to both the sodium and the associated oil industries.

C. The production of alumina from aluminum phosphate rock does not appear economically feasible even if P_2O_5 were recovered as a by-product. Only increased return from potential additional by-products, such as uranium and cement ingredients, could change the economic outlook.

D. The production of alumina from anorthosite does not appear economically practicable using present technology because of the high processing costs.

E. The recovery of alumina from copper leach solutions may prove economic but does not represent a potentially large source of supply.

F. Today, insufficient information is available to evaluate saprolite or aluminous shale as potential domestic sources of alumina. Very large tonnages of aluminous saprolite exist and could be strip mined after removal of a thin layer of soil. Although aluminous shale is inexhaustible, no action is recommended presently on this source.

G. The quantities of ash generated at any one place are insufficient to be considered as a raw material of aluminum. Future restrictive requirements on atmospheric pollution might reduce further the amount of ash generated at localities where aluminous raw material would be desired. The use of coal ash as a source of alumina also may be lessened by the following: (1) the wide range of alumina contents of ash make raw material quality control difficult or costly and (2) much coal ash has been so vitrified that the alumina present is in a relatively insoluble form.

H. Alunite has little potential of being a major raw material of aluminum in this country because all known deposits are either small and scattered or have the mineral disseminated through volcanic rock. Alumina extracted from such material would not be competitive in price.

I. To date, none of the new reduction technologies which have been developed -- including direct reduction -- have been attractive economically.

J. The electrolysis of aluminum chloride, based on current attempts, is unlikely to compete successfully with the Hall process. Future technological advances in materials of construction might permit a different conclusion.

Appendix 2

METHODOLOGY FOR IMPORT PROJECTIONS

To establish dollar flows attributable to bauxite and alumina imports, it was necessary to project through 1985 the imports of bauxite and alumina. Sources of data were primarily the Mineral Yearbook (1969) and Mineral Facts and Problems (1970), both published by the U. S. Bureau of Mines, and Processes for Extracting Alumina from Nonbauxite Ores, a report of the National Materials Advisory Board (1970). The data shown in Appendix Table 1 were analyzed by

Appendix Table 1

ACTUAL AND PROJECTED IMPORTS OF BAUXITE AND ALUMINA, 1965-1975
(Aluminum content in thousands of short tons)

Year	Bauxite	Alumina
1965	3,233	120
1966	3,321	259
1967	3,342	504
1968	3,166	697
1969	3,474	997
1970	3,667	1,084
1971	3,776	1,369
1972	3,879	1,644
1973	3,988	1,892
1974	4,094	2,171
1975	4,252	2,500

Source: National Materials Advisory Board, Processes for Extracting Alumina from Nonbauxite Ores, Publication NMAB-278, December 1970, p. 9.

fitting linear and non-linear functions to determine which curve best fit the data. The following equations fitted to the data were chosen for use in the estimation of imports of bauxite and alumina in aluminum equivalents:

Bauxite

$$y = 468.118\, e^{.02929x}$$

y = imports of bauxite in aluminum equivalent

x = year; where 1965 equals 65

$$R^2 = .933$$

Alumina

$$y = -15328.1 + 236.164x$$

y = imports of alumina in aluminum equivalent

x = year; where 1965 equals 65

$$R^2 = .993$$